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YEARLY INDEX

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The Blast Furnace and Steel Plant

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The following is an index of feature articles appearing in THE BLAST FURNACE AND STEEL PLANT from January through December, 1922. In addition to the articles included in this index the following departments appear regularly each month:

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Future Success Depends Upon Improved Methods of Production

DURING the five years preceding 1921, the whole thought of those in charge of the iron and steel industry was production, and technical developments were of secondary consideration. During all this time the engineers and operating officials pleaded only for a breathing spell, in which time obsolete and worn-out equipment could be replaced, new plants constructed, and new developments completed.

The year 1921 brought forth this very opportunity, as the steel industry was at low ebb. Consequently, no year in the history of the industry has been more replete with engineering activities, no year has seen greater interest displayed in improvments, and in no year has there been more definite applicable knowledge disseminated. These facts afford a material foundation for a spirit of optimism which is the dominant element in the expansion of industry.

Industrial depression constitutes an incentive to economize in materials, stimulates efforts to improve methods of production, and checks numerous minor wastes which inevitably develop in times of intense industrial activity. Thus a period of depression is not an unmitigated evil; such a period merely represents the inertia inherent in readjustment of the industrial structure, and recent conditions should have a salutary effect in stabilizing the mechanism of industry.

We therefore predict that the greatest advances in the history of the industry will take place during the next few years, and confidently look forward to an early resumption of activity and a revival of prosperity in the iron and steel industry.

The Steel Industry During 1921

Depression in Steel Industry During the Past Year Due to the Liquidation of Material in Intermediate Hands, Rather Than a Cessation of Consumption by the Ultimate User.

By B. E. V. LUTY

IT GOES without saying that the year 1921 was a year of "readjustment" in the iron and steel trade, as it was in all commercial lines. One scans a year of history to see what has been accomplished, so 1921 is to be studied to see what progress was made in this readjustment.

It is palpably plain that the iron and steel industry completed its readjustment as far as lay in its power. The iron and steel consuming industry did not do as much—not, probably, because it did not try as hard, but because it was controlled in part by circumstances over which it had no control.

That is, the steel producing industry reduced its prices to a very fair level, and did not consume anything like all of the year in doing so, but the consumers, those to whom the steel industry sells, were in control of those to whom they in turn sell, and the ultimate consumer or investor did not get in position to take hold freely. The result was a restricted market.

Course of Steel Prices.

The year of 1921 being largely a year of "readjustment" and as the word as lately used connotes price readjustment more than any other one particular thing, the course of steel prices deserves first consideration in a review of the year. A composite finished steel, or weighted average of the important finished steel products, devised by the writer, permits a study of price movements without use of a complicated mass of figures. The composite is made up of 2½ pounds each of shapes, plates, wire nails and pipe, one pound of sheets and a half pound of tin plate In dollars and cents per net ton this composite finished steel has been as follows:

Ten-year average, 1904-1913......	$36.00
1913 average	34.40
Low, December, 1914...........	28.40
High, July, 1917...............	116.00
Government war control..........	76.00
Industrial Board, March 21, 1919..	65.00
High, August, 1920.............	77.00*
January 1, 1921................	65.00
December 31, 1921.............	45.20

It will be recalled that the prices set by agreement between the steel makers and Secretary Redfield's Industrial Board, four months after the armistice, were announced as being prices that were fair for everyone to proceed upon. They averaged $11 a ton under the control prices of the government during the war. At first the prices seemed to many buyers to be too high. Afterwards, in 1920, prices of independents advanced much higher, while the Steel Corporation held to the Industrial Board prices. Late in 1920 the independents returned to the Steel Corporation prices, so that 1921 opened with the steel market precisely at the old Industrial Board level. During the year steel prices fell approximately one cent a pound, and more than three-fourths of this decline occurred during the first seven months of the year.

As time passed the perspective in which the existing price level of steel products was viewed underwent a fundamental change. When prices first began to decline from the war control they were considered from the viewpoint of how much they had declined. Men saw only the war prices and used them as the standard. There were men who professed to be shocked at the temerity of anyone who thought of comparing prices with those existing before the war. In the course of time the perspective changed, and in 1921 men had no patience with comparisons showing how much prices had declined. What they were interested in was the amount by which prices were higher than pre-war levels. The above presentation of finished steel prices enables all desirable comparisons to be made. Steel prices in December, 1921, were 26 per cent above the 10-year pre-war average, 31 per cent above the 1913 average and 59 per cent above the 1914 low, which was the lowest since 1898 and only a trifle above the low point in all the history of the steel industry.

The Bureau of Labor's index number of prices of all commodities at wholesale is regarded as the best weighted of all the index numbers, and the bureau's practice of making all its comparisons by reference to the average of 1913 fully sanctions this basis. The bureau's index number declined to about 150 (1913=100) by the middle of 1921, and hovered around that level during the second half of the year. Correspondingly finished steel would stand at 131, or 19 points below commodities in general. Thus steel has carried its liquidation farther than other commodities on an average. That is not all the story. There has been liquidation in everything but freight rates, and freight rates are an important part of the cost of making pig iron and steel. The advance in the freight rates that apply to the iron and steel industry was greater than the advance in freight rates in general. Handicapped by having a large part of its cost in an entirely unliquidated item, the steel industry has gone beyond industries in general in liquidating its prices.

Production.

Production of pig iron in 1921 was approximately 16,500,000 gross tons of pig iron and a trifle less than 20,000,000 gross tons of steel ingots, the production of finished rolled steel, in bars, shapes, plates, pipe, wire rods, sheets, etc., being slightly under 15,000,000 gross tons or between 16,000,000 and 17,000,000 net tons.

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*Average of Steel Corporation prices, independent prices for forward delivery and independent prices for prompt delivery.

These estimates compare with officially reported production (gross tons) as follows:

	Pig Iron	*Ingots*
1890.........	9,202,703	4,250,000
1900.........	13,789,242	10,000,000
1910.........	27,303,567	25,154,089
1913.........	30,966,152	30,284,130
1916.........	39,434,797	41,401,917
1917.........	38,621,216	43,619,200
1918.........	39,054,644	43,051,022
1919.........	31,015,364	33,694,795
1920.........	36,925,897	40,881,392
1921.........	16,500,000	19,500,000

The steel market has been quite accustomed to ups and downs. It has required very little, apparently, in the past to send prices upward and just as little to send them downwards. Right in the middle of the industrial depression of 1893 to 1898 the steel market had a sharp upward swing, in the latter part of 1895, afterwards called "the soda-water rise." Afterwards, to the opening of the World War in 1914, the market had five upward swings and as many downward swings. Each time, when prices were found to be higher than buyers would continue to support, it has been sapiently remarked in the trade that buyers did not have large stocks of steel, hence it would not take long to readjust—the buyers would soon be back in the market again. Each time the appraisal was found to be wrong. The buyers did have large stocks. At the beginning of 1921 the observation was made with redoubled confidence. Certainly this time buyers had not loaded themselves with steel, for prices were exceptionally, dangerously and discouragingly high in 1920. It was found, however, that if anything the condition as to stocks was worse than ever, for not only were there large stocks of unused steel in the hands of buyers, both jobbers and manufacturing consumers, there were also large stocks of manufactured goods, of tools, machinery, agricultural implements and all sorts of things. All these stocks had to be liquidated or passed on to the ultimate consumer or user. During the process the production of steel dropped, at about the middle of July, to less than 20 per cent of capacity, a rate of just 10,000,000 tons of ingots a year.

There is no question that this represented liquidation of material in intermediate hands, not a cessation of consumption by the ultimate user. The people had not stopped doing things. Probably the best general measure of the commercial activity of the country is the bank debits reported by the Federal Reserve Board, the total of debits to individual accounts at banks. These debits show the volume of business being done. In the four weeks ended July 20, 1921, the bank debits showed a lag of only 19 per cent below the debits in the same period of 1920. This was the money turnover, and as prices, salaries, wages, dividends, etc., had increased more than 19 per cent the physical volume of business was greater. The production of steel ingots, by comparison, showed a lag of no less than 75 per cent. Obviously the ultimate consumption or employment of steel did not decrease by three-fourths.

Details of Production.

The year 1921 opened with production of steel ingots at the rate of 29,000,000 tons a year. Except for a slight recovery in May there was a steady decline to the 10,000,000-ton rate of mid-July. Then there was a fairly steady recovery until a rate of slightly over 25,000,000 tons was reached at the end of October. In the last two months of the year there was a slight tapering off, this being merely a reflection of the season of the year. In the closing months of the year consumption or employment of steel was, except for seasonal influences, at a rate represented by about 25,000,000 tons of ingots a year.

Ordinarily the distribution of production among the different finishing branches of the industry varies but little from one year to another, but in 1921 the relative tonnage of the various finished products showed quite an unusual alignment. Of course, there have been some great variations over long periods. For instance, there was a heavy production of rails in 1887, and it was not until 1899 that as large a production was made, yet meanwhile the production of pig iron doubled. Structural shapes rose from practically nothing to a very substantial tonnage. In 1906 rod production was half the rail production, while in 1914 rods passed rails and have stayed ahead ever since. These, however, are long range comparisons.

The times are unsettled and no one can say just what men will be busy about in future, so that it is impossible to determine just how abnormal was the distribution of steel in the different finished products in 1921, but taking the average of the preceding 10 years as a standard, it may be said that the proportion of steel passing into welded tubular products, particularly oil country goods, into sheets and into wire products, was abnormally large, while the proportion passing into bars, shapes and plates was abnormally small. The proportion of steel passing into rails was practically normal, much loose talk in and out of the trade to the contrary notwithstanding. This point could be dwelt upon and the matter elucidated in detail, but it is not worth while to discuss so unimportant a subject as rails. In a normal year the tonnage of rails required for replacements on the regular steam roads will approximately equal the tonnage of tin plate, a material that sells for two and a half times as much per ton as rails. Production of tin plate was relatively light in 1921, not because ultimate consumption was light, but because large stocks of goods prepared in tin plate containers had been carried over from 1920, partly because the holders shrank from taking the losses they were ultimately forced to accept.

Barometers and Percentages.

Many a true word is spoken in jest, and this perhaps refers in particular to a remark of the late Josh Billings, that "It's a great deal better not to know so many things than to know so many things that ain't so." Also it has been observed that a little knowledge is a dangerous thing. This is apropos the adage that "iron (or steel) is the barometer of trade" and the continued talk of the steel industry operating at this or that percentage. In the last four months of 1921 the steel industry operated at various rates between 30 and 50 per cent of its capacity. Men who had been taught to believe that steel was the barometer and who were told that steel was running at these low percentages were disposed to adopt the view that trade, or commerce in general, was at a very low ebb. Bank debits, already referred to above, ran throughout 1921 at a lag of between 15 and 20 per cent below those of 1920, while on account of the decrease in prices, salaries and wages, the lag in total volume of commerce must have been less than this, and probably showed an increase rather than a lag. Men in general, however, have not been taught to study bank debits. Freight ton-mileage on the railroads, despite the alleged great handicap of high freight rates, was 75 per cent as great in the first eight months of 1921 as in the first eight months of 1920, when lower freight rates were in effect.

If steel were considered in terms of tons instead of terms of per cent the index would be more trustworthy. The percentage comparison tacitly assumes that whatever steel making capacity exists must operate substantially full, preferably with orders banked up and consumers waiting for deliveries, or the commerce of the country is in bad condition. The people of the United States, however, can do only so much work. If they do more of one kind they must do less of another. Greater results can be accomplished with the same amount of work if efficiency is increased through improvements in methods and appliances, but on account of the war there has been less advancement in the past few years than formerly. The 1920 census showed an increase, over 1910, of 9 per cent in the number of persons gainfully employed. It is a question whether the quantity of work per person increased at all. In 1910, which was a record year in its time, the United States produced 25,154,087 tons of ingots. A 20 per cent increase in 12 years, when the number of workers increased only 9 per cent in ten years, would make 30,000,000 tons of ingots, and that would be a 57 per cent operation of the steel industry. The 30,000,000 tons would look good, the 57 per cent would look bad.

The country can call for steel at such a rate as will require more than a 30,000,000 ton production on either of two bases: First, that by increases in efficiency of fabrication and utilization more steel can be handled by the same number of persons than in 1910; second, that by doing less work of other descriptions more work can be done in using steel. There does not seem to be any other method.

In the past there have been changes of both descriptions, whereby the tonnage of steel has grown rapidly. Lumber and brick have been replaced by steel in the erection of buildings. Just now building trades labor is engaged chiefly in erecting garages and dwelling houses, which consume little steel in proportion to the work done, rather than bridges, factories, skyscrapers and power plants, which require a great deal of steel. The railroads are striving for greater freight moving capacity by increasing the efficiency, moving a freight car more miles per day, rather than adding largely to the number of cars occupying tracks. The oil industry on the other hand is using steel very freely, for the production of oil must be kept up and year by year it requires more steel to produce a given quantity of oil. The labor involved per ton of steel employed is relatively small.

The foregoing argument is very general in character. It is made, not as a finality, but merely to suggest a general principle that seems to be rarely recognized. The argument has one loose end in particular. The average farmer does have some spare time, and can consume more steel than he has consumed lately, without neglecting other kinds of work, but what the farmer does need before being in position to consume steel freely is higher prices for his products or lower prices for the things he buys.

Review of Iron and Steel Literature for 1921

A Classified List of the More Important Books, Serials and Trade Publications During the Year, With a Few of Earlier Date, Not Previously Announced.

By E. H. McCLELLAND
Technology Librarian, Carnegie Library of Pittsburgh

THIS, the fourth annual review of the literature of iron and steel prepared for THE BLAST FURNACE AND STEEL PLANT, lists a greater number of publications than any preceding review. This is, in part, due to the increasing number of trade publications, many of the more meritorious of which have been included in the classified list below. Due to the praiseworthy efforts of the manufacturers issuing these publications, the literature of the year has been notably enriched.

Where possible, the works listed have been personally examined by the compiler of this review. Certain publications, however, were not available and the only information regarding them was in reviews in technical journals, which in many cases failed to give adequate data.

A few book reviews are referred to below. Many others are listed in the *Technical Book Review Index* published quarterly by the Carnegie Library of Pittsburgh.

The best guide to the extensive current literature of ferrous metallurgy is the *Journal of the Iron and Steel Institute*, two recent volumes of which are mentioned below.

GENERAL.

Geology, Metallurgy, Testing.

Aal, N. H.—Diagrammes d'équilibre de transformation des aciers spéciaux. 27 pages. 1921. Gauthier-Villars, Paris.

Aitchison, Leslie—Engineering Steels. 397 pages. Macdonald & Evans, London. 25 sh. net.

"Briefly explains how this or that steel is made; what are the special qualities and features of the available varieties, with their chemical proportions, peculiar physical and mechanical properties, and how all these factors contribute to the usefulness of the several grades or limit their application to practical ends."—*Ironmonger*, Sept. 3, 1921, p. 100.

American Institute of Mining and Metallurgical Engineers—Pyrometry. 701 pages. 1920. The Institute, New York.

A symposium at Chicago meeting, September, 1919. Contains some 60 papers, with considerable discussion.

American Iron and Steel Institute—Year Book. 536 pages. 1921. The Institute, New York.

Contains papers at meetings of May and October, 1920.

American Rolling Mill Company—Armco in Picture and Fact. 1921. The Company, Middletown, Ohio.

"A non-technical and pictorial description of the manufacture of iron and steel, and containing, besides general reference data, computing tables, and other useful information, for sheet-metal workers."—*Iron and Coal Trades Review*, Sept. 2, 1921, p. 304.

American Rolling Mill Company—Research and Methods of Analysis of Iron and Steel at Armco. Ed. 2, 220 pages. 1920. The Company, Middletown, Ohio. $4.

Includes sections on corrosion, magnetic testing, and metallurgical control, including microscopical and physical testing.

American Society for Testing Materials—A. S. T. M. Standards, Issued Triennially. 890 pages. 1921. The Society, Philadelphia.

Devotes 378 pages to ferrous metals, and has sections also on coal and coke, preservative coatings, testing of metallic materials, and preparation of micrographs.

Association of Iron and Steel Electrical Engineers—Proceedings, Thirteenth Annual Convention, 1920. 700 pages. 1921. The Association, Pittsburgh. $5.

An important feature of the present volume is a symposium on steam-driven vs. electrically driven mills, with charts of high technical value.

Backert, A. O.—A B C of Iron and Steel. Ed. 4. 408 pages. 1921. Penton Publishing, Co., Cleveland. $5.

Collection of monographs by various authors. In Ed. 4, treatment of rolling mill industry is extended, and chapters are added on manufacture of rails, tubes, and tin-plate. The directory of steel works has been revised and is of great value.

Binz, A.—Kohle und Eisen. Ed. 2. 120 pages. 1919. Tuelle & Meyers, Leipsic. 250 marks.

Brooks, Alfred H. and La Croix, M. F.—Iron and Associated Industries of Lorraine, the Sarre District, Luxemburg, and Belgium. 131 pages. 1920. (United States Geological Survey. Bulletin 703.) Government Printing Office, Washington, D. C.

In addition to statistical and economic information, considers geology and metallurgy.

Carnegie Steel Company—Blast Furnace Slag; Data on Its Preparation, Properties and Commercial Uses. 38 pages. 1921. The Company, Pittsburgh.

Shows value as concrete aggregate, for ballast, and in road construction.

Carnegie Steel Company—General Statistics and Special Treatise on Homestead Steel Works. 60 pages. 1921. The Company, Pittsburgh.

Pamphlet, illustrating equipment and outlining processes at Homestead.

Carnegie Steel Company—Industrial Wheels, Gear Blanks and Other Circular Forgings. 45 pages. 1921. The Company, Pittsburgh.

Comite des Forges de France—La Siderurgie Francaise, 1864-1914. 626 pages. 1920. Paris.

Copper Clad Steel Company—Aristos "Copperweld" Copper Clad Steel Wire. 99 pages. 1921. The Company, Rankin, Pa.

Dichmann, Karl—Die basische Herdofenprozess. Ed. 2. 278 pages. 1920. Julius Springer, Berlin. 50 marks.

Durand, A.—Organisation et conduite des aciéries Martin. Part I: Les Gazogènes. Libraire de L'Usine, Paris. 6 francs.

Reviewed in *La Fonderie Moderne*, Jan., 1921, p. 16.

England—Geological Survey—Special Reports on the Mineral Resources of Great Britain.

Vol. 8: Iron Ores (Contd.), Precarboniferous and Carboniferous Bedded Ores of England and Wales; by Sir A. Strahan and others. 123 pages. 1920. 7 sh. 6 d. net.

"It is here brought out clearly that the production of iron ore from the coal-measures is now of trifling importance, and though much smelting is still done in the coal fields, this is solely because of the presence of coal and not of iron ore."—*Geological Magazine*, Feb., 1921, p. 86.

England—Research Department—Effect of Overstrain on the Elastic Properties of Steel. 1920. (Report No. 45.) H. M. Stationery Office, London. 2 sh. 1 d. postpaid.

Gages, L.—Cours de métallurgie. Ed. 2. 5 vol. 1920-21. Librairie de l'Enseignement Technique, Paris.

v.1: La fonte. 334 pages. 20 fr.
v.2: Elaboration des fers et des aciers. 351 pages.
v.3: Travail des fers et des aciers. 431 pages.
v.4: Essais mécaniques des fontes, des aciers et des fers. 320 pages.

v.5: Métallurgie des alliages métalliques et des métaux autres que le fer. 432 pages.

A comprehensive work, vol. 1-2 of which were listed in this Review for 1920.

Galassini, Alfred—Elementi di siderurgia e di tecnologia meccanica. 669 pages. 1920. Societá Tipografico, Turin. 50 lire.

Geuze, L.—Traité theorique et pratique du laminage du fer et de l'acier. Ed. 2. 2 vols. 1921.

Vol. 1: Text. 280 pages.
Vol. 2: Plates (84).

Hall, William T. and Williams, R. S.—Chemical and Metallographic Examination of Iron, Steel and Brass. 501 pages. 1921. McGraw-Hill Book Co., New York. $5.

A selection of rapid and accurate chemical methods occupies the greater part of the book. Some 30 pages are devoted to electrometric methods and about 100 pages to metallography of iron and steel.

Horner, J. G.—Smithing and Forging. 1921. Emmott & Co., London. 8 sh. 6 d.

Hoyt, Samuel E.—Metallography. Part 2: The Metals and Common Alloys. 462 pages. 1921. McGraw-Hill Book Co., New York.

Part 2 describes metals and alloys, devoting 297 pages to "Steel and Cast Iron" and "Special Steels." Part 1 deals with "Principles," and Part 3 (in preparation) with "Technical Practice."

Institution of Automobile Engineers—Report of the Steel Research Committee Founded by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders on an Investigation Conducted to Establish the Mechanical Properties of the British Standard Wrought Automobile Steels, and Factors Governing Testing Procedure in Connection Therewith. 72 pages. 1920. The Institution, Sheffield. 32 sh.

Deals with ten standard automobile steels.

Iron and Steel Institute—Journal. Vol. 102. 423 pages. 1920. Vol. 103. 524 pages. 1921. The Institute, London.

Containing original papers on ferrous metallurgy and numerous abstracts of the current literature in all languages.

Moldenke, Richard—Charcoal Iron 64 pages. 1920. Salisbury Iron Corporation, Lime Rock. Conn.

History and metallurgical information.

Pickands, Mather & Company—Cargo Analyses; Lake Superior Iron Ores, for Season 1920. 19 pages. 1921. The Company, Cleveland.

Portevin, A.—Pyometrie. Cementation. 1920. Charles Lavauzelle, Paris.

Preuss, E.—Die praktische Nutzanwendung der Pruefung des Eisens durch Aetzverfahren und mit Hilfe des Mikroskops. Ed. 2. 131 pages. 1921. Julius Springer, Berlin.

Roesler, Max—Iron Ore Resources of Europe. 152 pages. 1921. Government Printing Office, Washington, D. C. (United States Geological Survey. Bulletin 706.)

Accompanied by maps. Bibliography of 25 pages.

Sauer, K.—Leitfaden der Huettenkunde fuer Maschinentechniker. 1920. Julius Springer, Berlin.

Spurr, J. E., ed.—Political and Commercial Geology, and the World's Mineral Resources; a Series of Studies by Specialtists. 562 pages. 1920. McGraw-Hill Book Co., New York. $5.

Technical and economic study. Has a chapter of some 35 pages on iron, and chapters on the various metals employed in alloy steels. A very valuable book.

Stainless Steel; Its Properties and Uses. 1921. Brown Bayley's Steel Works, Ltd., Sheffield, England.

Pamphlet for the assistance of those interested in manufacturing wares of stainless steel. Gives composition and properties of several brands, considering also Brearley's "stainless iron."

Standard Alloys Company—Uranium in Steel. 32 pages. 1921. The Company, Pittsburgh.

Discusses uranium, its influence on steel, analytical methods, and physical tests of uranium steel.

Steel Company of Canada, Ltd.—Standard Specifications. 84 pages. 1920. The Company, Hamilton, Ont.

Reprint of various specifications of American Society for Testing Materials, Lloyd's Register, Master Car Builders' Association and Manufacturers' Standards.

Tafel, Wilhelm—Walzen and Walzenkalibrieren. 228 pages. 1921. Wilh. Ruhfus, Dortmund. $2.25.

Theoretical work, with 161 illustrations and 8 folding plates. Reviewed in BLAST FURNACE AND STEEL PLANT, Sept., 1921, p. 570.

United States Steel Corporation—Chemists' Committee—Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Ferro-Alloys and Bearing Metals. 71 pages. c1920. J. M. Camp, Carnegie Building, Pittsburgh.

Van Dyke, G.—Shop Handbook on Alloy Steels; a Technical Subject Treated in a Non-Technical Way. 95 pages. 1921. Joseph T. Ryerson & Son, Chicago.

Useful manual by manager, Special Steel Department. Outlines manufacture, gives suggestions for use of alloy steels and includes certain specifications and tables.

Verein Deutscher Eisenhuettenleute.—Gemeinfassliche Darstelling des Eisenhuettenwesens. Ed. 11. 594 pages. 1921. Vertag Stahleisen, Dusseldorf. 60 marks.

Vulcan Crucible Steel Company—High Grade Tool Steels and Special Steels. 94 pages n. d. (Catalogue No. 6.) The Company, Aliquippa, Pa.

Gives suggestions for use.

Willem, Jules—Traité elementaire de metallurgie et de technologie metallurgique. New. ed. revised. 365 pages. 1920. P. Martino, Seraing, France. 30 fr. 75.

Greater part is devoted to ferrous metallurgy. Contains folding plates.

Wuest, Fritz, ed.—Mitteilung aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf. 1920. Verlag Stahleisen, Duesseldorf.

Economics and Statistics.

American Hardware Jobbers' Directory of the United States and Canada, and Trade Name Index. Seventh annual edition. 268 pages. 1920. E. G. Baltz, Pittsburgh. $2.50.

Cotter, Arundel—United States Steel; a Corporation With a Soul. 312 pages. Doubleday, Page & Co., Garden City, N. Y. $3 net.

Revision and enlargement of author's "Authentic History of the United States Steel Corporation." 1916.

Grabe, Alf., comp.—Iron and Steel in Sweden. 183 pages. 1921? Swedish Chamber of Commerce in the United States, New York.

Information regarding iron and steel and their products available for export.

Lloyd, D. W. and Barnett, A. P., ed.—Business Prospects Year Book. 1921. Business Statistics Co., Cardiff. 10 sh. net.

British annual, summarizing the business outlook in various industries, including iron and steel.

Metal Statistics. Ed. 14. 560 pages. 1921. American Metal Market Co., New York. $1.

A valuable annual, characterized by promptness in appearance, and by concise arrangement. Presents an immense amount of statistical information on ferrous and non-ferrous metals.

Mineral Industry During 1920. 907 pages. 1921. McGraw-Hill Book Co., New York. $10.

Section on iron and steel by E. F. Cone contains statistics and review of technical progress during 1920.

Northern Coal, Iron and Steel Companies. Business Statistics Co., Cardiff. 1 sh. 8 d. postpaid.

Annual booklet, giving financial statistics of British companies. Primarily for the investor.

Pawlowski, Auguste—La Metallurgie du fer dans le nord et l'est envahis; hier, aujourd'hui, demain. 288 pages. 1920. L'Information Universelle, Paris.

Reviewed in *La Nature*, March 19, 1921, sup. p. 96.

Peters, Richard, Jr.—Two Centuries of Iron Smelting in Pennsylvania. 79 pages. 1921. Pulaski Iron Co., Philadelphia.

Valuable historical information.

Pothmann, Wilhelm—Zur Frage der Eisen- und Manganerzversorgung der deutschen Industrie. 312 pages. 1920. 24 marks.

Revewed in *Stahl und Eisen*, October 21, 1920, p. 1430.

South Wales Coal and Iron Companies. 1921. Business Statistics Co., Cardiff. 2 sh. 6 d. postpaid.

British booklet, published annually. Financial statistics of companies, primarily for investors.

Coke.

Biddulph-Smith, Thomas—Coke-Oven and By-Product Works Chemistry. 180 pages. 1921. Charles Griffin & Co., London. 21 sh. 6 d.

Concise British manual for chemical control of plants.

Carnegie Library of Pittsburgh—By-Product Coking; References to Literature, May 1915-June 1921, Supplementing a List Compiled in the Technology Department and Published in the Monthly Bulletin of the Library, May, 1915. 18 pages. 1921. The Library, Pittsburgh.

Mimeograph copy.

Christopher, J. E. and Byrom, T. H.—Modern Coking Practice. Ed. 3. 2 vol. Crosby, Lockwood & Son, London. $8.

Vol. 1: Raw Materials and Coke. 130 pages.
Vol. 2: By-Products. 130 pages.

Daniels, Joseph—The Coking Industry of the Northwest. 35 pages. 1920. University of Washington, Seattle. (Engineering Experiment Station Series. Bulletin 9.)

Deals especially with the industry in Washington and British Columbia, and with undeveloped resources of Oregon and Alaska.

Electric Furnace.

Borchers, Wilhelm—Die elektrische Ofen. Ed. 3. 289 pages. Wilhelm Knapp, Halle a. Saale.

Dickmann, Herbert—Bibliographie ueber die Darstellung des Roheisens im elektrischen Ofen. 15 pages. 1921. Verlag Stahleisen, Duesseldorf. 6 marks.

Includes literature in books and journals, 1899-1920. Reviewed in *Staht und Eisen*, Aug. 18, 1921, p. 1169.

Electric Furnace Association—Refractories for Electris Furnaces. 80 pages. 1921? The Association, Niagara Falls, N. Y.

Papers and discussions at meeting of Oct. 6, 1920.

Escard, Jean—L'Electrométallurgie du fer et de ses alliages. 811 pages. 1920. Dunod & Pinat, Paris. 45 francs.

Discusses the electric furnace in steel manufacture and in the foundry; ferro-alloys; electrolytic iron; electric welding and heat treatment; and electromagnetic treatment of ores.

Moissan, Henri—Electric Furnace; translated by Victor Lenher. Ed. 2. 313 pages. 920. Chemical Publishing Co., Easton, Pa.

"This is a second edition of the translation of the author's *Le Four Electrique,* Paris, 1897, the first edition having appeared in 1904. No attempt has been made to add in any way to the text of the original French edition."—*American Journal of Science,* April, 1921, p. 367.

Pring, J. N.—The Electric Furnace. 485 pages. 1921. Longmans, Green & Co., New York. $10.50.

Fairly technical work covering general field, but devoting some 200 pages to production of iron, steel, and ferro-alloys, and consideration of furnace refractories.

Foundry Practice.

The American Foundrymen's Association, co-operating with the National Research Council, has published in mimeograph form a bibliography of 82 pages on "Refractories Used in Foundries" (October, 1921), and one of 66 pages on "Natural and Synthetic Foundry Sands and Clays and Employment of Greater Proportions of Used Sand in Molding and Core-Making Operations" (September, 1921).

Carman, Edwin S.—Foundry Moulding Machines and Pattern Equipment. Ed. 2. 225 pages. c1920. Penton Publishing Co., Cleveland. $5.

Excellent practical guide to the use of various types of molding machines, and the pattern and flask equipment necessary for their use. Of value to everyone interested in foundry practice.

Duponchelle, J.—Comment on pratique la fonderie. 500 pages. Dunod & Pinat, Paris. 52 francs.

Reviewed in *La Fonderie Moderne,* April, 1921, p. 86.

Farrell-Cheek Steel Foundry Company—Illustrated Story of a Farrell-Cheek Steel Casting. 41 pages. 1921. The Company, Sandusky, Ohio.

Irresberger, Carl—Die Formstoffe der Eisen- und Stahlgiesserei; ihr Wesen, ihre Pruefung und Aufbereitung. 245 pages. 1920. Julius Springer, Berlin. 24 marks.

McCracken, Edward M. and Sampson, C. H.—Pattern-Making. 111 pages. 1921. D. Van Nostrand Co., New York. $2.

Manuel complet du fondeur en fer et en cuivre. New ed. 2 vols. L. Mulo, Paris. 9 francs, unbound.

Osann, Bernhard—Lehrbuch der Eisen- und Stahlgiesserei. Revised and enlarged. 1920. W. Engelmann, Leipsic.

Reviewed in *Feuerungstechnik,* March 15, 1921, p. 110.

Pitt, George J.—Iron Foundry Practice. 1921? Cassell & Co., London. 6 sh. net.

Author is instructor in iron founding, Sydney Technical College, New South Wales.

Schott, Ernst A.—Die Metallgiesserei. Ed. 2, revised and enlarged. 397 pages. B. F. Voigt, Leipsic. 37.50 marks.

Reviewed in *Stahl und Eisen,* Oct. 28, 1920, p. 1469.

Schott, Ernst A. and Einenkel, A.—Giesserei-Materialkunde. 331 pages. 1920. Hermann Meusser, Berlin. 48 marks.

Detailed consideration of foundry practice with ferrous and non-ferrous metals, fuels and foundry accessories; and chemical, physical and metallographic testing.

Shaw, Ben, and Edgar, James—Foundrywork. 115 pages. 1921. Sir Isaac Pitman & Sons, New York. $1.

Brief, elementary guide to methods in iron and brass foundries. Based on British practice.

Shaw, Ben, and Edgar, James—Patternmaking. 108 pages. 1921. Sir Isaac Pitman & Sons, New York. $1.

Treiber, E.—Giessereimaschinen. 1920. Gruyter & Co., Berlin. 2.10 marks.

Fuel and Refractories.

Frion—Le chauffage au charbon pulverisé. 32 pages. 1921. Chaleur & Industrie, Paris.

Larcheveque, Marc—Terres refractaires. Ed. 2. 76 pages. n. d. G. & M. Marin, Vierzon, France.

Considerable information about composition and properties of refractory clays and sands. Little attention to applications.

Muenzinger, F.—Kohlenstaubfeuerungen fuer ortsfeste Dampfkessel. 124 pages. 1921. Julius Springer, Berlin. 24 marks.

Refractories Manufacturers Association—Brands of Fire Brick and Other Refractories. Ed. 3. 40 pages. 1921. (Frederic W. Donahoe, 840 Oliver Building, Pittsburgh.)

An alphabetical list of brand and trade names with the manufacturer of each, and an alphabetical list of manufacturers with the brands manufactured.

Sexton, A. Humboldt—Fuel and Refractory Materials; Revised and Enlarged by W. B. Davidson. 382 pages. 1921? Blackie & Son, London. 12 sh. 6 d. net.

Contains much new matter, the chapter on by-products having been practically rewritten, with considerable attention to low-temperature carbonization.

Heat Treatment.

Brearley, Harry—Case-Hardening of Steel; an Illustrated Exposition of the Changes in Structure and Properties Induced by Cementation and Allied Processes. Ed. 2. 207 pages. 1921. Longmans, Green & Co., New York. $6.

Valuable practical work.

Brearley, Harry—Le traitement thermique des aciers a outils; translated by Navant. Libraire Loubat & Cie, Paris.

Colvin, Fred H. and Juthe, K. A.—The Working of

Steel; Annealing, Heat Treating and Hardening of Carbon and Alloy Steel. 245 pages. 1921. McGraw-Hill Book Co., New York. $3.

Authors are, respectively, editor of *American Machinist*, and Chief Engineer of American Metallurgical Corporation. Well written.

Driver-Harris Company—Case Carbonizing. 111 pages. 1920. The Company, Harrison, N. J.

Discusses, also, cyanide hardening, gas hardening, lead tempering, and the properties and uses of "Nichrome."

England—Research Department—Heat Treatment of Carbon Gun Steels. 1920. (Report No. 48.) H. M. Stationery Office, London. 6 sh. 8 d. postpaid.

England—Research Department—Heat Treatment of Nickel Gun Steel. 1921. (Report No. 49.) H. M. Stationery Office, London. 3 sh. 7½ d. postpaid.

Supplementary to Report No. 9, which had reference to time and temperature of tempering. Present report deals chiefly with microstructure as related to heat treatment, and effect of various rates of cooling through the critical range.

Giolitti, Federico—Heat Treatment of Soft and Medium Steels; Theory and Practice of the Preliminary Heat Treatments to Give Maximum Toughness to Steels Used for Machine Parts; translated by E. E. Thum and D. G. Vernaci. 374 pages. 1921. McGraw-Hill Book Company, New York.

Much hitherto unpublished information.

Guillet, L.—La trempe et le revenu des produits metallurgiques. 264 pages. 1921. Octave-Doin et Fils, Paris. 6 francs.

Reviewed in *La Nature*, April 23, 1921, sup. 6. 136.

Millett, Kenneth B.—Cooling of Quenching Oil in the Heat Treatment of Steel. 29 pages. 1921. Griscom-Russell Co., New York.

Discusses various quenching mediums and describes Griscom-Russell cooling equipment.

Hygiene.

Brundage, Dean K.—Diseases Prevalent Among Steel Workers in a Pennsylvania City. 14 pages. 1921. Government Printing Office, Washington, D. C. (Public health reports. Reprint 632.)

Forms pages 3163-3171 of report for December 31, 1920.

England—Industrial Fatigue Research Board—Fatigue and Efficiency in the Iron and Steel Industry; Summary of Contents of Report No. 5 of the Industrial Fatigue Research Board. 1921? H. M. Stationery Office, London. 3 sh.

Based on investigations of numerous iron and steel works in England, Scotland and Wales. As a result of reduction from 12-hour to 8-hour shifts open hearth production increased two to nine per cent, but there was no change in output of blast furnaces and rolling mills.

UNITED STATES BUREAU OF STANDARDS PUBLICATIONS.

Certain 1920-21 publications of the United States Bureau of Standards likely to interest chemists and metallurgists in the steel industry are grouped together below for economy of space. They may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Circulars.

No. 26—Analyzed Iron and Manganese Ores; Methods of Analysis. Ed. 4. 20 pages. 1921. 5 cents.

No. 42—Metallographic Testing. Ed. 2. 11 pages. 1921. 5 cents.

Scientific Papers.

No. 376—Chemical Ranges of Some Commercial Nickel Steels, by Howard Scott. 195-214 pages. 1920. 5 cents.

No. 395—Relation of the High-Temperature Treatment of High-Speed Steel to Secondary Hardening and Red Hardness, by Howard Scott. 521-536 pages. 1920. 10 cents.

No. 396—Thermal and Physical Changes Accompanying the Heating of Hardened Carbon Steels, by Howard Scott and H. Gretchen Movius. 537-556 pages. 1920. 5 cents.

No. 397—A Study of the Relation Between the Brinell Hardness and the Grain Size of Annealed Carbon Steels, by Henry S. Rawdon and Emilio Jimeno-Gil. 557-593 pages. 1920. 10 cents.

No. 402—Use of Ammonium Persulphate for Revealing the Macrostructure of Iron and Steel, by Henry S. Rawdon. 715-723 pages. 1920. 5 cents.

No. 404—Magnetic Reluctivity Relationship as Related to Certain Structures of a Eutectoid-Carbon Steel, by C. Nusbaum, W. L. Cheney and H. Scott. 739-757 pages. 1920. 5 cents.

No. 408—Effect of the Rate of Cooling on the Magnetic and Other Properties of an Annealed Eutectoid Carbon Steel, by C. Nusbaum and W. L. Cheney. 65-78 pages. 1921. 5 cents.

Technologic Papers.

No. 165—Enamels for Sheet Iron and Steel, by J. B. Shaw. 88 pages. 1920. 5 cents.

No. 72—Cast Iron for Locomotive Cylinder Parts, by C. H. Strand. 25 pages. 1920. 10 cents.

No. 178—Steel Rails from Sink-Head and Ordinary Rail Ingots, by George K. Burgess. 61 pages. 1921. 20 cents.

No. 179—Electric-Arc Welding of Steel: 1. Properties of the Arc-Fused Metal, by H. S. Rawdon, E. C. Grossbeck and L. Jordan. 63 pages. 1921. 15 cents.

Chronological bibliography, 52 references.

No. 191—Some Factors Affecting the Life of Machine-Gun Barrels, by W. W. Sveshnikoff. 27 pages. 10 cents.

No. 192—Tests of Centrifugally Cast Steel, by George K. Burgess. 22 pages. 1921. 10 cents.

CAMDEN IRON WORKS SOLD.

The Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., has purchased from the receivers of the Camden Iron Works, Camden, N. J., all patent rights, patterns, etc., used in the manufacture of hydraulic tools and high-pressure valves. The Camden Iron Works has sold for many years through R. D. Wood & Co. of Philadelphia and others. The purchase of the Birdsboro Steel Foundry & Machine Co. includes the machinery, jigs, templets, etc., required for the production of operating valves and all stock which was in process of manufacture at the time of purchase. This deal places the Birdsboro Steel Foundry & Machine Co. in a position to supply hydraulic equipment of every character.

A part of the plant of the Camden Iron Works has been purchased by the U. S. Cast Iron Pipe & Foundry Co., Philadelphia.

Progress in Iron and Steel Metallurgy

General Improvements Shown in the Sintering of Ore, Open Hearth Furnace Construction and in the Treatment of Steel Products—Electric Furnace Standardized.

By J. M. HALL*

TO OPERATORS of blast furnaces perhaps the most interesting developments during the year 1921 are the experiments carried out in Canada on the smelting of Titaniferous iron ores, and the continued progress in the development of the great project for concentrating and sintering the lean iron ores of the East Mesabi district.

Heretofore in the smelting of Titaniferous iron ores the titanium has been considered an acid and lime has been used as in ordinary practice. As titanium is neutral or amphoteric (i. e., its oxide will take the place either of an acid or of a base in a slag), it is possible to use silica instead of lime as a flux for these ores. In the experiments above mentioned this was done, and the results secured are said to have been very encouraging and the slags in every way satisfactory. Should further trials confirm the results of the preliminary experiments, a vast amount of iron ore containing titanium as well as silica will be made available.

As is well known to readers of The Blast Furnace and Steel Plant, the Mesabi Iron Company controls an area of 12 to 15 square miles of territory in the Eastern Mesabi district, in which lies a vast deposit of lean iron ore which is being developed on an enormous scale. These ores are to be crushed, concentrated by magnetic methods and sintered. Already the first unit of the sintering plant has been constructed with a capacity of 1,000 tons of sinter in 24 hours. The ultimate capacity of the plant is to be 30,000 tons of sinter per day. The product is already on the market.

In steel works practice very radical changes are being made in the construction of the ports of open hearth furnaces with a view to increasing the life of the port, speeding up the operation of the furnace and burning by-product coke oven gas more satisfactorily than has been possible heretofore. It is especially noteworthy that after a long period in which very little change has been made in the design of open hearth furnaces radical departures in design should be proposed and successfully tried out by at least two independent inventors.

At the plant of the Brier Hill Steel Company the Egler design has been tried out for producer gas. In this type of furnace, positive pressure by means of a blower is applied to both air and gas. The latter comes up a flue at the extreme end of the furnace in a position corresponding to that of the air flue in the old design. This flue is turned downward to form the port in the usual manner, but the air is brought up a flue placed between the gas flue and the hearth of the furnace in such a manner that the air rises vertically into the gas flue some distance back of the mouth of the port. The gas and air are intimately mixed before leaving the port, and the flame is introduced into the furnace very much in the manner of the flame of a blow torch. It is said that the port temperatures are not unduly high, and that the roof is protected by a small moving body of air which is furnished by the small excess supplied over that needed for combustion.

In addition to the flues mentioned, there are two auxiliary flues at each end of the furnace leading to the checkers which can be closed at will by means of water cooled mushroom valves. In the end of the furnace where the flame is entering, these flues are closed while those at the discharge end are opened. In this manner the rate of flow of the producers of combustion is decreased at the discharge end of the furnace. A very high hearth temperature and very perfect transmission of the heat to the bath has been secured, and the output of the furnace has been very high. Furnaces have been designed also for burning coke oven gas, natural gas, oil and tar.

The McKune design was first tried out for the burning of by-product coke oven gas in the plant of the Steel Company of Canada. In general the principle adopted is very similar to that of the Egler design inasmuch as both types are designed to slow down the products of combustion at the outgoing end of the furnace.

In the furnace as built there are three vertical flues leading up from the well in front of the checkers. As in the Egler design, two of these flues are closed at the incoming end of the furnace by suitable dampers; the corresponding pair at the outgoing end are left open. The air at the incoming end is introduced under a blower pressure of about 6 ounces and comes up the central flue, which turns over to form the port. The gas is introduced through pipes on each side of the center port at right angles, and is very thoroughly mixed with the air and burns completely in the first 10 feet of the hearth. The results secured are quite as encouraging as those at Brier Hill.

At the South Chicago works of the Steel Corporation, what is called the Venturi line furnace has been developed and tried out, the general design being more or less on the McKune principle. Producer gas is burned and the furnace is under induced fan draft to take care of the waste heat boilers. The port area is decreased by lowering the roof knuckles and moving the wing walls in such a way as to give a restricted opening in two planes. In addition, the mouth of the gas port is moved about three feet back of the point of greatest restriction so that a channel exists where air and gas mix after leaving the mouth of the port proper and before entering the hearth. This design has resulted in improved life of the gas port or block, and in better operation of the furnace.

At the same plant a combination of the McKune and Venturi line designs is being worked out in which water cooled dampers, one on either side of the gas port, take the place of the knuckles in the side wall in the original Venturi line design. In operation these dampers are lowered into position at the incoming end of the furnace and raised at the outgoing end, giving an area of 13 square feet where the products of combustion leave the hearth. The air is forced in by a fan and as the furnace has waste heat boilers, induced draft is used at the stack end. The results secured in improved operation of the furnace and increased output have been highly encouraging.

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*The author is metallurgist for the Taylor-Wharton Iron & Steel Company, High Bridge, New Jersey.

In electric furnace work the most striking development of the year has been the successful starting up of the 40-ton Heroult electric furnaces in the government armor plate plant. These furnaces are round with a shell 18 ft. in diameter and 8 ft. high, with 18-in. brick walls. Three electrodes are used which are 24-in. in diameter for amorphous carbon, and 14-in. for graphite which has been tried experimentally. The furnaces take hot metal from two 75 basic open hearth furnaces in which the phosphorous is reduced to about .015 per cent and in the electric furnace the metal is refined and the sulphur brought down to between .008 and .015 per cent. The problems encountered in designing these 40-ton furnaces called for great skill and ingenuity and we are informed confidentially that the next step will be to a much larger furnace and that the 100-ton electric furnace is in sight.

The Electric Furnace Association has been investigating the most desirable voltages for the manufacture of electric steel, and has concluded tentatively that the shorter arc and lower voltages are on the whole more desirable in the manufacture of high grade steel.

The General Electric Company is experimenting with a 2-ton induction furnace of new design in which the primary coils are above the bath instead of on the same level with it, and in which other new features have been introduced. Following the unsatisfactory showing of induction furnaces in this country in the past, the progress of this type will be watched with interest.

In foundry work the building of the Ford plant, which will eventually have a capacity of 2,500 tons of castings a day, is progressing successfully. This is probably the first plant designed to use direct metal from the blast furnaces on a large scale, and already with the four mechanically charged cupolas which have been started the use of direct metal has been a success. The iron from the blast furnaces is brought to the foundry in 75-ton ladle cars whence it is transferred to 20-ton ladles in which the cupola iron and direct metal are mixed. Proportions varying from 40 per cent direct and 60 per cent cupola metal to 60 per cent direct and 40 per cent cupola metal have been successfully used and even in some cases 80 per cent direct metal with 20 per cent cupola iron has been poured. The ratio contemplated, however, for regular work is about 50 per cent direct metal and 50 per cent cupola iron.

The Malleable Iron Association has published a bulletin in which they call attention to the great improvement in the average quality of the tests submitted by their members, especially in the last three and one-half years. During this time the average tensile strength of the test bars has increased from a little under 49,000 pounds per square inch to over 53,000 pounds per square inch, and the elongation in 2-inch from under 10 per cent to nearly 16 per cent. The association feels that this data represents real progress in the improvement of their product of which they may well be proud.

In Germany oil has been successfully used in a cupola to decrease the consumption of coke. The methods followed were somewhat similar to those of Mr. Stoughton and the results appear to have been similar.

A very interesting article was published during the year describing the operation of four 60-ton basic open hearth furnaces with hot metal melted in two cupolas 6 ft. in diameter inside of the lining and 30 ft. high to the charging door. This practice was tried during repairs to the plant's blast furnace in order to secure a higher output than was possible with cold charges. The two cupolas were in operation on an average of 18 hours out of a possible 24, and supplied the four open hearth furnaces regularly with 50 tons of hot metal each. During the run some 13,000 tons of iron were melted with quite satisfactory results, and the author of the article believes that in some cases such a process would be worth adopting for a plant having open hearth furnaces but no blast furnace.

Although nothing strikingly new has come up in electric heat treatment, the number of furnaces in operation is steadily increasing, and the range of temperatures possible in these furnaces has been extended. Although in many cases the operation is more costly than that of fuel fired furnaces, yet the superior control of temperatures and the comparative freedom from oxidation and scaling makes electric heat treatment extremely desirable for many classes of products.

Lap welded pipe is now being made by a new process in sizes from 24 in. to 96 in. These pipes are made from high grade open hearth steel bent either hot or cold in rolls very much like those used for forming the shells of boilers, and the weld is made a section at a time by heating the lap inside and outside with gas burners and forming the weld with a power hammer. The pipe is then annealed and afterwards straightened, inspected and tested in the usual manner. The thickness of these pipes range from ¼ in. to 1¼ in. and the product is used in places where cast iron pipe is not strong enough. These smooth pipes are preferable to riveted joint pipe because, owing to the absence of friction a smaller size can be used to carry the same quantity of water.

It is very encouraging to note that in spite of the severe depression in the iron and steel business so much large scale experimentation has been carried out during the year with such encouraging results.

NATIONAL ASSOCIATION OF COST ACCOUNTANTS.

The National Association of Cost Accountants has recently inaugurated a drive for 400 new members by March 1st, 1922. This organization is national in scope and has members in practically every State in the Union in addition to some in Canada, Mexico and Europe.

There are local chapters in most of the principal cities of the United States. These chapters meet monthly to hear various messages by reputable cost authorities on cost and accounting problems. These local chapters are the clearing house where cost data and plans are exchanged by representative cost men and accountants.

Membership is not confined to men alone as there are several women members now in the Association. All men and women interested in cost accounting are invited to investigate the merits of the organization with a view to becoming active members. Mr. S. C. McLeod, 130 West 42nd St., New York City, is the National Secretary and Business Agent.

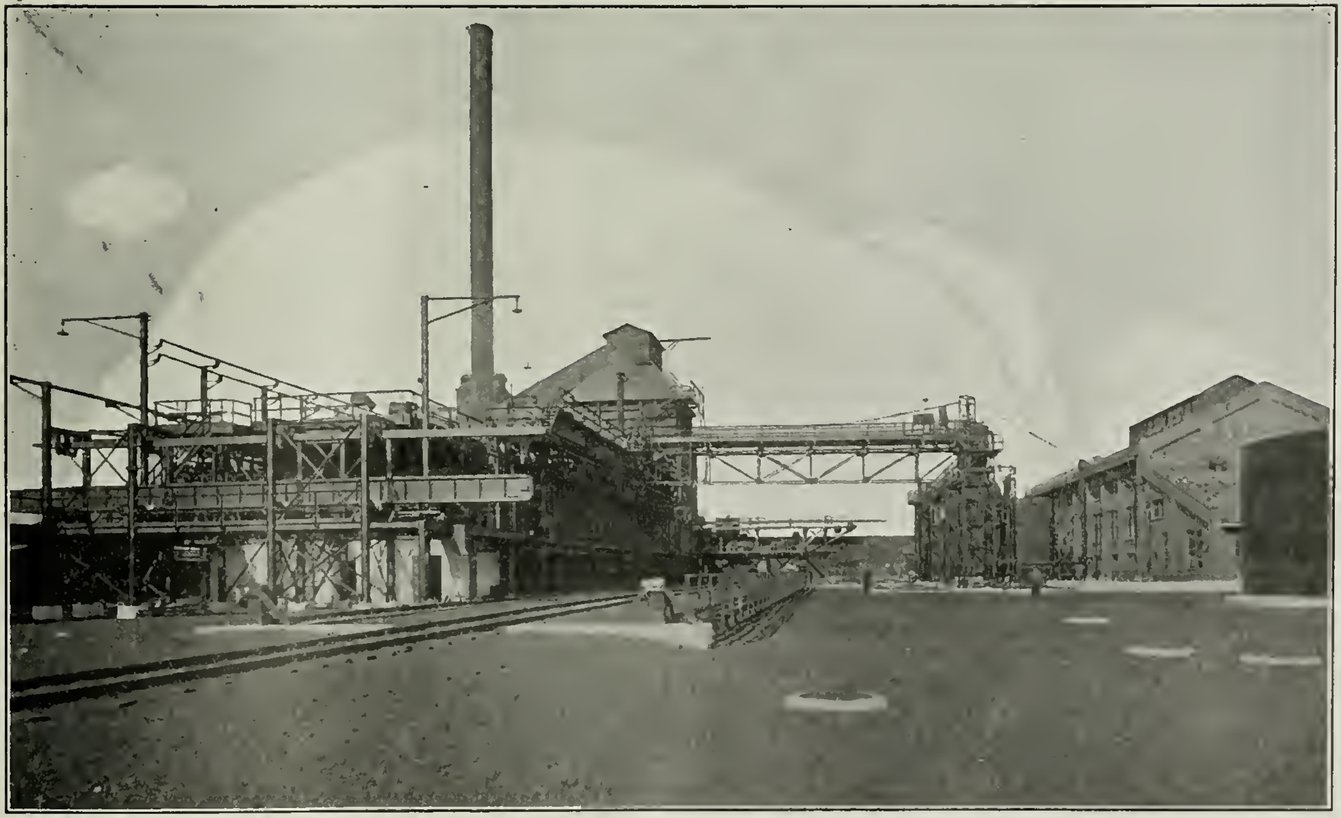
By-Product Coke Oven Department

New By-Product Coke Oven Plants at Johnstown, Pa.
By J. M. HASTINGS, JR.

European By-Product Coking Industry During 1921
By A. THAU

The By-Product Coke Oven Industry 1921
By C. J. RAMSBURG

Recent Development in Steel Mill Cranes
By GORDON FOX



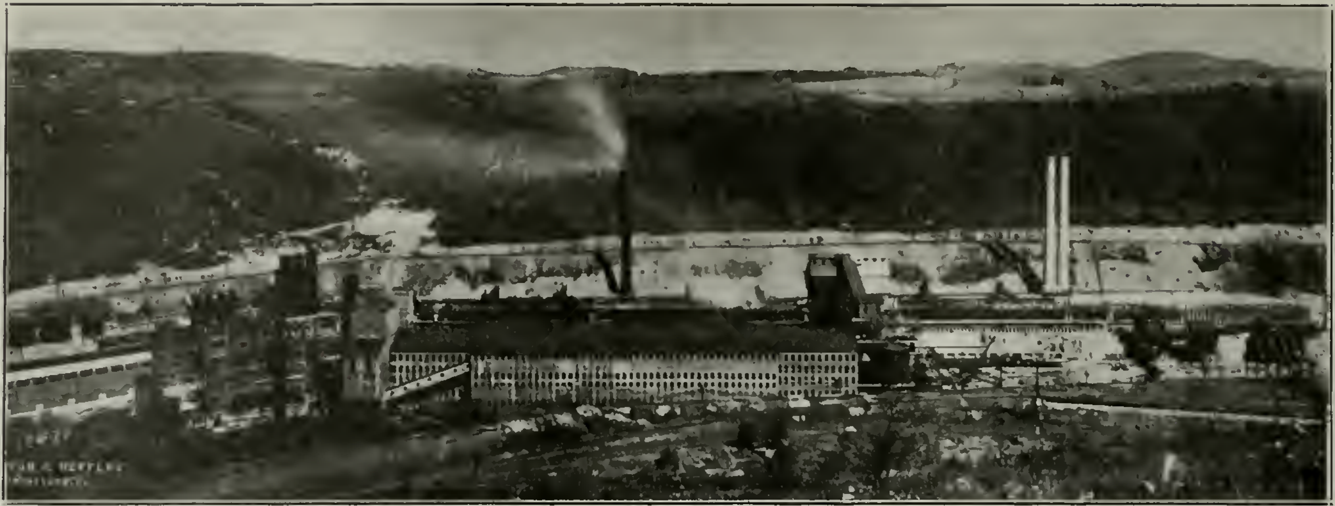


Fig. 1—General view of Rosedale Plant. Left to right: Sulphate storage and by-product building, boiler house, gas washers and coolers, coal preparation, washing and mixing buildings, ovens, coke handling building.

New By-Product Coke Oven Plants

Semet-Solvay Company Completes Fifteen Million Dollar Plants for the Cambria Steel Company at Johnstown, Pa.—The Rosedale and Franklin Plants Described.

By J. M. HASTINGS, JR.*

OCTOBER, 1921, marked the completion by the Semet-Solvay Company of the largest and most difficult by-product coke oven construction contract ever undertaken—largest in view of the actual amounts involved and most difficult on account of the peculiar engineering problems to be solved. This article gives a brief description of the results accomplished during 14 months' work and outlines a few of the difficulties which were successfully overcome.

At Johnstown, Pa., the Cambria Steel Company operates two separate coke oven plants, located about three miles apart, the Rosedale plant supplying coke to the six Cambria furnaces, and the Franklin plant supplying the five Franklin furnaces. The construction work undertaken at Rosedale included the entire by-product coking process from the delivery of coal at the mine head shaft to the production of coke and by-products. At Franklin the new construction began at the point where the gas left the ovens and included complete by-product recovery equipment with the necessary auxiliaries. All the work on both plants was performed by the Semet-Solvay Company. Since the plants are entirely separate, the description is divided into two parts, Rosedale and Franklin.

Rosedale Plant.

Before starting the new work, there was in operation at Rosedale one block of Cambria type ovens with partial by-product recovery, the coal for which was received from the Franklin washery, three miles away.

To eliminate this expensive coal haul, the Semet-Solvay Company erected a mine head shaft in the center of the Hinckston Run Valley, immediately below the oven batteries, tapping Rosedale Mines Nos. 5 and 6. This shaft is 405 feet overall from the mine gallery, 232 feet below ground, to the top of the hoist. A double skip hoist, each skip of eight tons capacity, operated by a 1,000-hp. motor driven, conical drum hoisting engine, provides a coal handling capacity of 6,000 gross tons per 10-hour day. Since the capacity of the present plant is 3,500 gross tons per day, an ample coal supply is thus assured.

This Rosedale coal from the Cement and Miller seams of the Kittanning veins is a low volatile coal with an average analysis about as follows:

Volatile	18.00 to 18.75%
Fixed carbon	70.0 to 72.0
Ash	10.0 to 11.5
Sulphur	2.1 to 2.4

To secure the desired quality of coke, high volatile coal must be mixed with this, the arrangements for which will be described later. Also the coal must be washed to reduce the sulphur and ash content. Accordingly from the head shaft skip, the coal passes through two 12x17-ft. Bradford breakers and by a 3-in. belt conveyor into the washery building. As it leaves the breakers, if desired, a part of the coal can be sent to a 250-ton loading-out bin for use at the boilers or elsewhere.

The washery building is 564 feet long by 99 feet wide and contains 72 Campbell washing tables and 10 draining pits, each of 1,550 tons capacity. These 10 pits are served by two reclaiming bridges equipped with continuous bucket diggers which deliver the washed coal to a

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*Mr. Hastings is with the Semet-Solvay Company, Syracuse, N. Y.

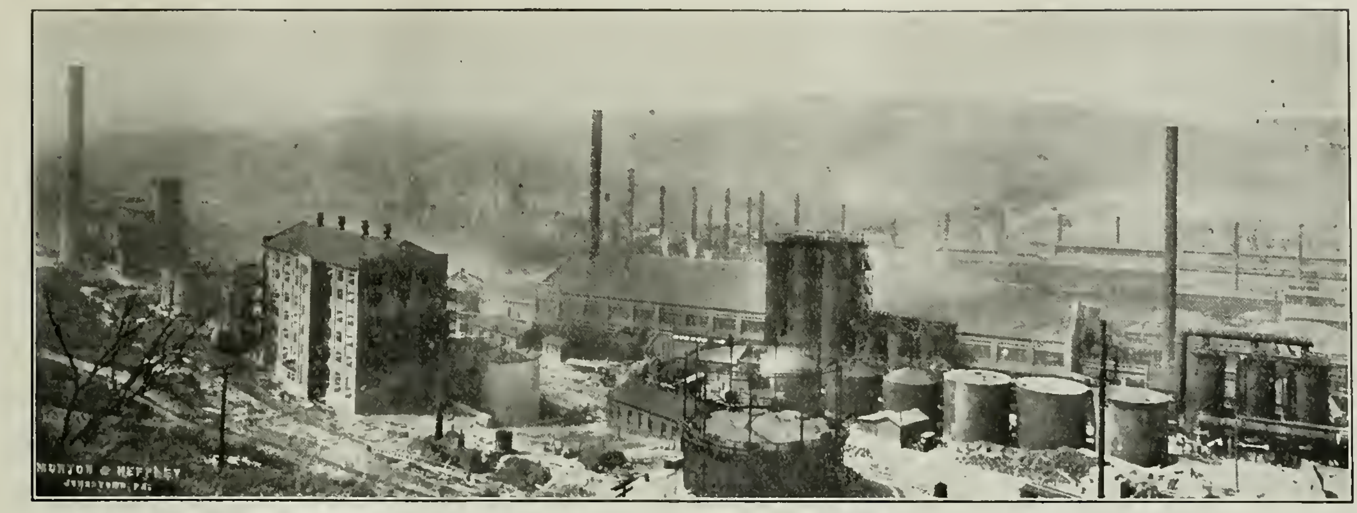

Fig. 2—General view of Franklin Plant. Left to right: Boiler house, benzol plant, by-product building, gas washing and cooling apparatus.

36-in. belt conveyor which in turn delivers to the mixing plant. Refuse from the washing tables falls into collector bins and thence into railroad cars.

This coal washing plant is the largest of its type ever built and has a capacity of 4,000 gross tons per 10-hour day. About 20 per cent of the ash and 50 per cent of the sulphur in the coal are removed by the washing process and the draining pits are so designed that the coal recovered contains only from 6 to 8 per cent moisture.

In the coal mixing plant, located at the eastern end of the washery building, a 250-ton bin is provided for the washed coal and a 1,000-ton circular bin for high volatile coal. This coal is received from cars at a track hopper, sent through a Bradford breaker and a double roll crusher and delivered by elevator to this circular bin. From these two bins, the high volatile and low volatile coals are delivered by short proportioning feeders into two spiral moving conveyors where intimate mixture is secured, it being possible to vary the mixture to contain from 20 per cent to 80 per cent high volatile coal. The mixed coal is then elevated by two belt bucket elevators, each of 200 tons per hour capacity, to two conveyor belts which deliver into the 3,000-ton coal bunker above the ovens.

The above described equipment provides a complete modern coal handling and washing plant which will supply the entire coal requirements of the ovens at a minimum expense.

Ovens.

As now completed there are four blocks with a total of 208 ovens at the Rosedale plant, having a total capacity of 3,500 gross tons of coal per day. Of this total, the 128 Cambria type ovens will take about 1,700 gross tons and the 88 Semet-Solvay ovens about 1,800 gross tons. All the ovens are of the modern regenerator type.

From these 3,500 tons of coal charged per day, products will be obtained approximately as follows:

Furnace coke	2,695 gr. tons
Domestic coke	40 gr. tons
Breeze	65 gr. tons
Sulphate of Ammonia...	104,000 lbs.
Light oil	12,000 gal.
Tar	32,000 gal.
Surplus gas	25,000,000 cu. ft.

Coke Handling.

Three 40-foot coke quenching cars operated by compressed air, each attached to a 27-ton electric locomotive, receive the coke as it is pushed from the ovens and proceed to one of the two brick quenching stations. The quenching operation requires about 55 seconds per oven. The quenched coke is dumped on a 200-foot inclined dock equipped with a rotary feeder at the foot, which delivers on to a 42-in. belt leading to the screening station.

At this point the oversize material is first removed by passing the coke over a rotary grizzly screen with 4-in. spaces. This oversize coke is crushed and delivered with the rest to a second rotary grizzly with ¾-in. spaces. All coke passing over this screen is conveyed by belt 250 feet across the valley to the furnace loading station and distributed by a shuttle conveyor to a specially designed 250-ton inclined bin which prevents breakage when the coke is loaded into cars.

The undersize coke passes to a domestic screen of the shaking type where the coke over ½-in. is separated for domestic use and the breeze is delivered to cars and returned to the plant boiler house.

By-Product Equipment.

Leaving the four blocks of ovens the gas enters a 78-in. common foul gas main leading to the primary coolers of which four are provided, each 10 feet in diameter by 45 feet high, arranged in parallel. These are of the well-known Semet-Solvay grid type in which the cooling is effectively performed by direct contact between the gas and a circulating liquor sprayed in at the top. This liquor is cooled after each contact with the gas by passage through 120 stacks of 2-in. cooling coils, each 30 pipes high, over which water is running. These gas coolers serve not only to cool the gas but also to condense and separate out practically all the tar and naphthalene.

It is interesting to note that due to the difference in rate of heat transfer through metals from water to water and from gas to water, the efficiency of the Semet-Solvay coolers is approximately 50 times that of the old type of tubular coolers. It is also of interest to note the well demonstrated facts that under normal operation these grid type coolers never require cleaning and that during the entire life of the plant there are no repair costs other than occasional renewals of spray nozzles

From this point the gas enters four Roots exhausters, each of 83.4 cu. ft. capacity per revolution, two being driven by 300-hp. motors and two by 15x22-in. Ridgeway engines. From the exhausters the gas passes through three 22,000,000-ft. capacity P. & A. tar extractors which remove the last traces of tar, and enters the three ammonia saturators. Here the gas comes in contact with a 5 per cent solution of sulphuric acid which absorbs as sulphate all the ammonia present.

Three final coolers in series, of the same design as the primary coolers, are next in line; there the gas is further cooled to about 20 deg. C. before entering the light oil scrubbers. The water circulated over the grids of these final coolers runs to a sump where any small amount of naphthalene remaining in the gas is brought down and collected and the water is pumped under 200-ft. head to a spray pond located 110 feet above on the hill side. From this pond the water returns by gravity to the tops of the final coolers. Tests on this spray pond have shown an actual cooling on favorable days to 3 deg. C. below the atmospheric temperature.

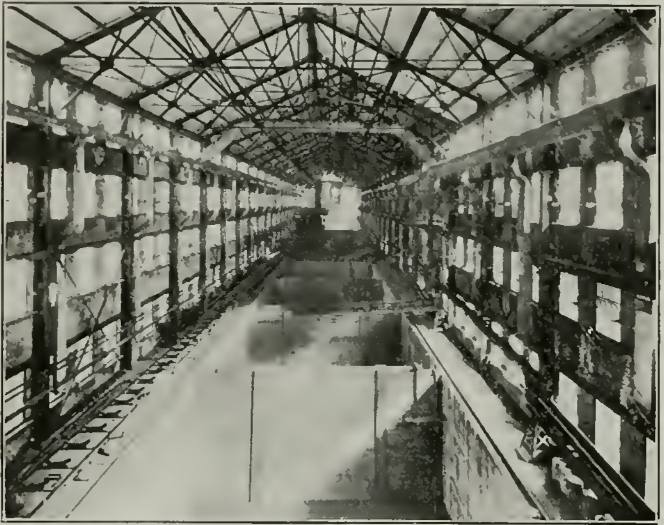

Fig. 3—Interior of coal washery.

The three light oil scrubbers are 16 feet in diameter and 90 feet high, filled with wooden grids similar to those in the coolers. A heavy petroleum absorbing oil is used to remove the light oils from the gas, the saturated oil being pumped to the light oil building.

The gas is now clean and ready for distribution. From 30 per cent to 35 per cent of the total is returned to the ovens for fuel gas and the remaining 65 to 70 per cent is pumped to the steel mills by two 150 cu. ft. Connersville exhausters, each driven by a 425-hp. twin Ball engine.

This surplus gas, estimated at 25 million feet per day, will replace in the mills approximately

500 tons of coal or
100,000 gallons fuel oil or
13,000,000 feet of natural gas or
100,000,000 feet of producer gas.

Ammonia Recovery.

Ammonia recovery in the Semet-Solvay system begins with the liquor circulation maintained on the collector or hydraulic main. By the use of numerous sprays at this point the gas is cooled to about 76 deg. C., relieving somewhat the load on the primary coolers, preventing effectively the formation of pitch deposits in the main and removing from the gas the fixed ammonia salts. Since the overflow from the primary cooler system is returned to the hydraulic main circulation, it is evident that the overflow from this latter circulation system will contain all the fixed ammonia, but very little free ammonia. This means a minimum volume of weak liquor requiring distillation and resultant low costs of ammonia recovery when sulphate is the desired product.

At the Rosedale plant one Semet-Solvay 6-ft. ammonia tank still has been provided which will handle readily all the weak liquor produced. The ammonia gas from this still enters the saturators with the oven gas for absorption as sulphate. At the Franklin plant a condenser has been installed in connection with the ammonia stills to permit the production of concentrated liquor if desired.

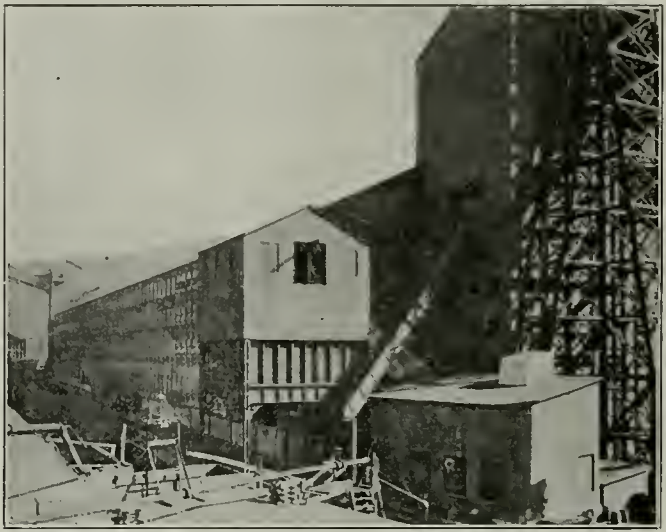

Fig. 4—Coal washery, Rosedale plant. Mine head shaft on right.

From the saturators, the crystallized sulphate of ammonia is delivered continuously by air ejectors to centrifugal dryers, of which nine are installed, three for each saturator, where it is dried and washed free of acid. From the dryers, a belt conveyor delivers the salt to the sulphate storage building, 176 feet long by 56 feet wide, where 4,000 tons can be stored. The salt can either be loaded out in bulk in cars or bagged as desired.

Light Oil Recovery.

From the light oil scrubbers, the absorbing oil carrying the light oils is pumped through a heat exchanger and a preheater into three Semet-Solvay stripping stills, which provide ample spare capacity. These are continuous stills, 6 feet in diameter, each with a capacity of 20,000 gallons per hour, in which the light oil is distilled off the absorbing oil, the former being condensed and the latter cooled and returned to the scrubbers. The Semet-Solvay system is notable for its high heat efficiency and for the fact that the separation of light oil and absorbing oil is so complete that no intermediate redistillation of the light oil is required before it is worked up into motor fuel or pure benzol, toluol and solvent. The absorbing oil is also thoroughly cleaned and washed in the process so that revivifying is never necessary.

From the Rosedale light oil plant, the light oil produced is shipped to the benzol plant at Franklin.

Auxiliary Equipment.

The new boiler house at Rosedale contains three 768-

hp. B. & W. boilers each equipped with a Coxe stoker for burning breeze. The plant is provided with track hopper, elevator and fuel bins for breeze or coal handling and a traveling bucket and skip hoist for removing ashes.

Two Bury air compressors have been installed, each directly connected to a 225-hp. motor. These have a combined capacity of 2,000 cu. ft. of free air per minute to supply the various needs of the plant.

In the transformer building are two 500-kw. 250-volt d.c. motor generator sets and one 500-kw. 275-volt synchronous converter for supplying the direct current required in the plant. High tension a.c. current from the steel plant power house is transformed for the coke oven plant by three 1,000-k.v.a. transformers.

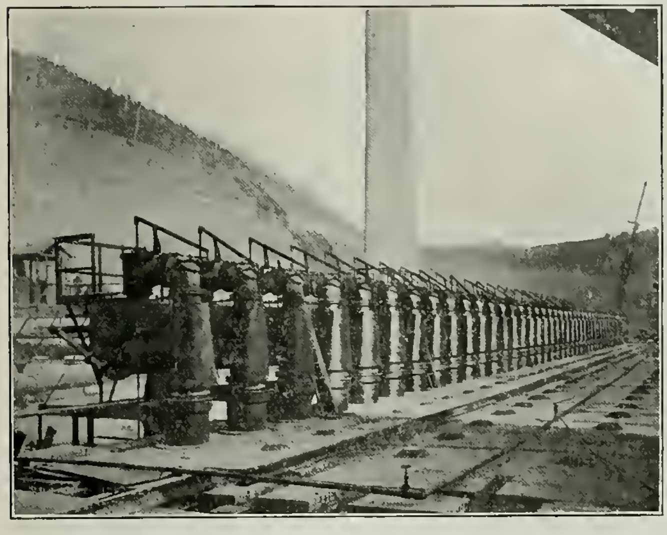

Fig. 5—Semet-Solvay ovens. Top of B1-3. Rosedale Plant.

Modern locker and toilet facilities are provided in the several buildings for the use of the men employed at those points. Throughout the plant every care has been taken to render the working conditions as safe and attractive to the men as possible.

Franklin Plant.

The old Franklin coke oven plant consisted of 11 batteries of ovens of various types, including one of the first blocks built in this country, with a total of 492 ovens having a capacity of 4,500 gross tons of coal per day. Partial recovery of by-products was undertaken in old type apparatus.

As the plant now stands no changes have been made to the ovens proper, but beginning at the points where gas leaves the oven chambers, the Semet-Solvay Company has installed complete modern by-product recovery apparatus which handles the entire gas output of the plant, including hydraulic main circulation systems, gas washing and condensing, tar, sulphate of ammonia, light oil and surplus gas recovery and benzol plant, boiler house and all necessary auxiliary equipment.

By-Product Equipment.

Leaving the ovens, the foul gas from five blocks enters one main and that from the remaining six blocks enters another, which combine in a single 60-in. main at the three primary coolers. These are of the Semet-Solvay grid type similar to those at Rosedale but somewhat larger, being 16 feet in diameter by 45 feet high. Each cooler has a capacity of 60,000,000 cu. ft. of gas per day. One hundred and sixty banks of cooling coils, each 30 pipes high, serve to cool the circulating liquor.

From the primary coolers, the gas enters the by-product building. This building, of steel and brick construction, as are all the other buildings, is 360 feet long by 83 feet wide. In this building are located the four DeLaval turbo exhausters, each of 14,000 cu. ft. per minute capacity, five P. & A. tar extractors and five Semet-Solvay saturators for ammonia recovery. The gas passes through these sets of apparatus in the order given and returns to the six final coolers and six light oil scrubbers outside the building, each in two sets of three in series. These are all 13 feet in diameter, the coolers being 45 feet high and the scrubbers 90 feet high. From this point a 42-in. line carries fuel gas to the boilers to take care of the Sunday gas and a 30-in. line delivers surplus gas to two turbine boosters and thence to the steel plant.

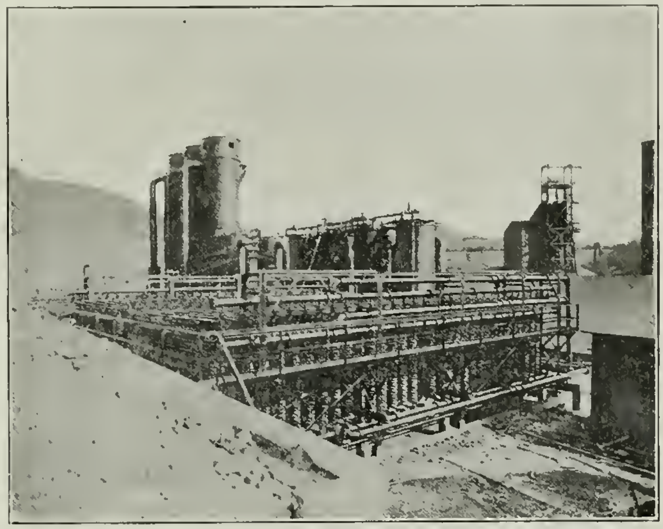

Fig. 6—Gas cooling and washing towers. Rosedale Plant. Cooling coils in foreground.

The ovens not being of the generator type, only 28,000,000 feet of surplus gas will be released per day at full operation. This 28,000,000 feet, however, will replace approximately:

570 tons of coal or
120,000 gallons of fuel oil or
15,000,000 feet of natural gas or
120,000,000 feet of producer gas.

It is interesting to note that the total surplus gas from the Rosedale and Franklin plants at full operation will replace daily:

1,070 tons of coal or
220,000 gallons of fuel oil,

which represents a direct saving to the Cambria Steel Company of from $5,000 to $10,000 per day.

The Franklin coke oven plant at full operation will produce per day by-products other than gas estimated as follows:

Tar	40,000 gal.
Sulphate of ammonia........	126,000 lbs.
Light oil	15,000 gal.

Ammonia Rrecovery.

Ten centrifugal dryers in the by-product building receive the sulphate precipitated out in the saturators and deliver the dried salt to a belt conveyor running into the storage room where 5,000 tons can be stocked. Available storage space is 160 feet by 83 feet. If desired the two stills provided to free the fixed ammonia and return it to the gas for absorption as sulphate can be used to make crude concentrated ammonia liquor since a condenser has been provided for that purpose.

The flexibility of operation is one of the outstanding features of the Semet-Solvay ammonia recovery system. When sulphate is the desired product, a minimum volume of ammonia liquor requiring distillation is produced, but if for any reason it becomes desirable to make concentrated liquor, the several circulation systems can be readily reversed and, with the addition of small amounts of water, a large proportion of the total ammonia in the gas may be recovered in the form of liquor. The ammonia recoverable as liquor in this way will vary from 15 per cent to 85 per cent of the total according to the coal used.

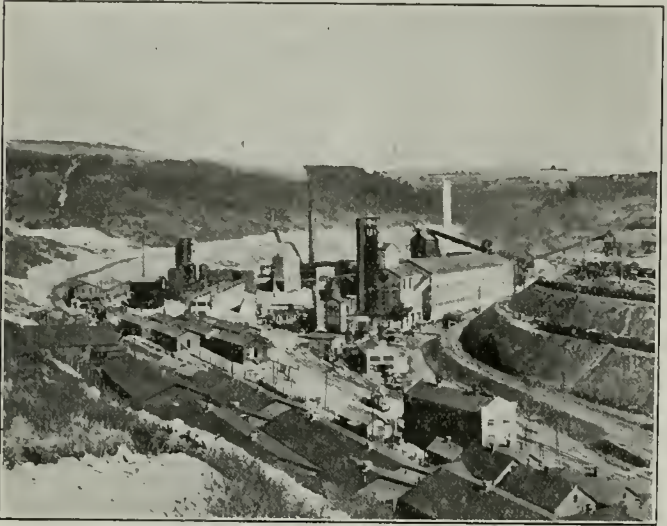

Fig. 7—General view of Rosedale Plant. Bunk houses and light oil building in foreground.

To permit this flexibility of operation, it is, of course, necessary that the stills provided have sufficient capacity. In this connection it should be noted that the efficient design of the Semet-Solvay stills insures a capacity of over four times that of any other type of still of equal size.

Light Oil Recovery.

In the benzol plant, four stripping stills are erected similar to those at Rosedale, with the usual equipment of preheaters, heat exchangers and Semet-Solvay system of decanters. Also in this building there are two motor benzol stills with light oil washing equipment and three intermittent stills for the production of pure benzol, toluol and solvent naphtha. In this plant all the light oil produced at Rosedale and Franklin is rectified with daily outputs of approximately:

22,000 gallons motor benzol, or
16,600 gallons pure benzol,
3,700 gallons pure toluol and
1,000 gallons solvent.

This plant is of standard Semet-Solvay design and is complete in every detail including storage tanks for all products and a drum loading station.

Auxiliary Equipment.

The new Franklin boiler house contains five 768-hp. B. & W. boilers, each equipped, as at Rosedale, with a Coxe stoker for burning breeze. These Coxe stokers give a boiler efficiency using breeze, which is comparable with the best resuts obtained with coal stokers.

A transformer building has been erected which contains three 500-k.v.a. transformers and motor generator equipment of sufficient size to furnish the direct current required in the plant.

The pumps used in the several operations are located in two separate pump houses providing the most satisfactory arrangement to meet local conditions.

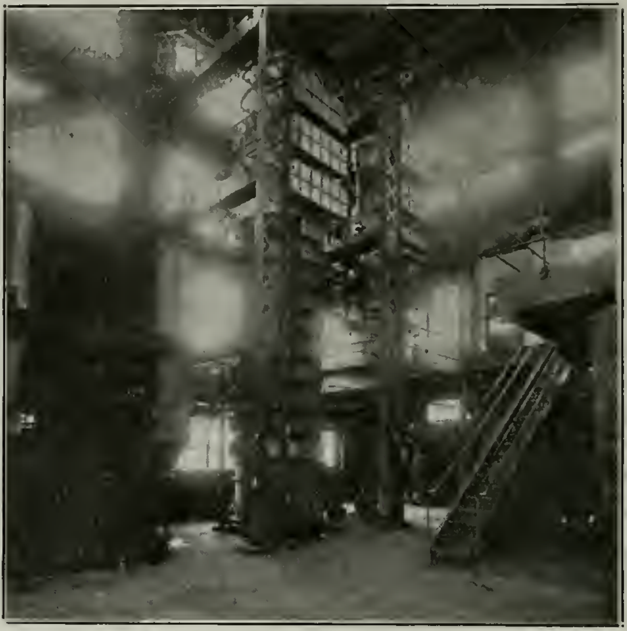

Fig. 8—Interior of by-products building, Franklin Plant, showing ammonia still and condenser.

Adequate locker and toilet facilities are provided throughout the Franklin plant, which, as now completed, represents in its entirety one of the finest examples of a by-product recovery plant to be found in this country.

Construction Features.

At the Franklin plant, aside from the usual troubles encountered in modifying existing equipment without serious interference with the operation, the construction work proceeded in an orderly manner and without undue difficulty. At Rosedale, however, due to local conditions, difficulties were encountered which required great engineering ingenuity to overcome.

Due to the narrowness of Hinckston Run valley it was necessary to construct the Rosedale plant on three distinct levels. On the upper level are the four oven blocks, on the middle level, the by-product buildings and equipment and on the lowest level the coal washery and coal handling equipment. In building these levels a total of over 150,000 cubic yards of excavation was required and 50,000 cubic yards of back fill. Two thousand linear feet of retaining walls were also necessary in which, including the various foundations, a total of 70,000 cubic yards of concrete was poured.

In laying the oven foundations, treacherous conditions were encountered unexpectedly, which made it necessary to sink caissons to solid rock. One hundred and fifty-six of these caissons were put down, six feet in

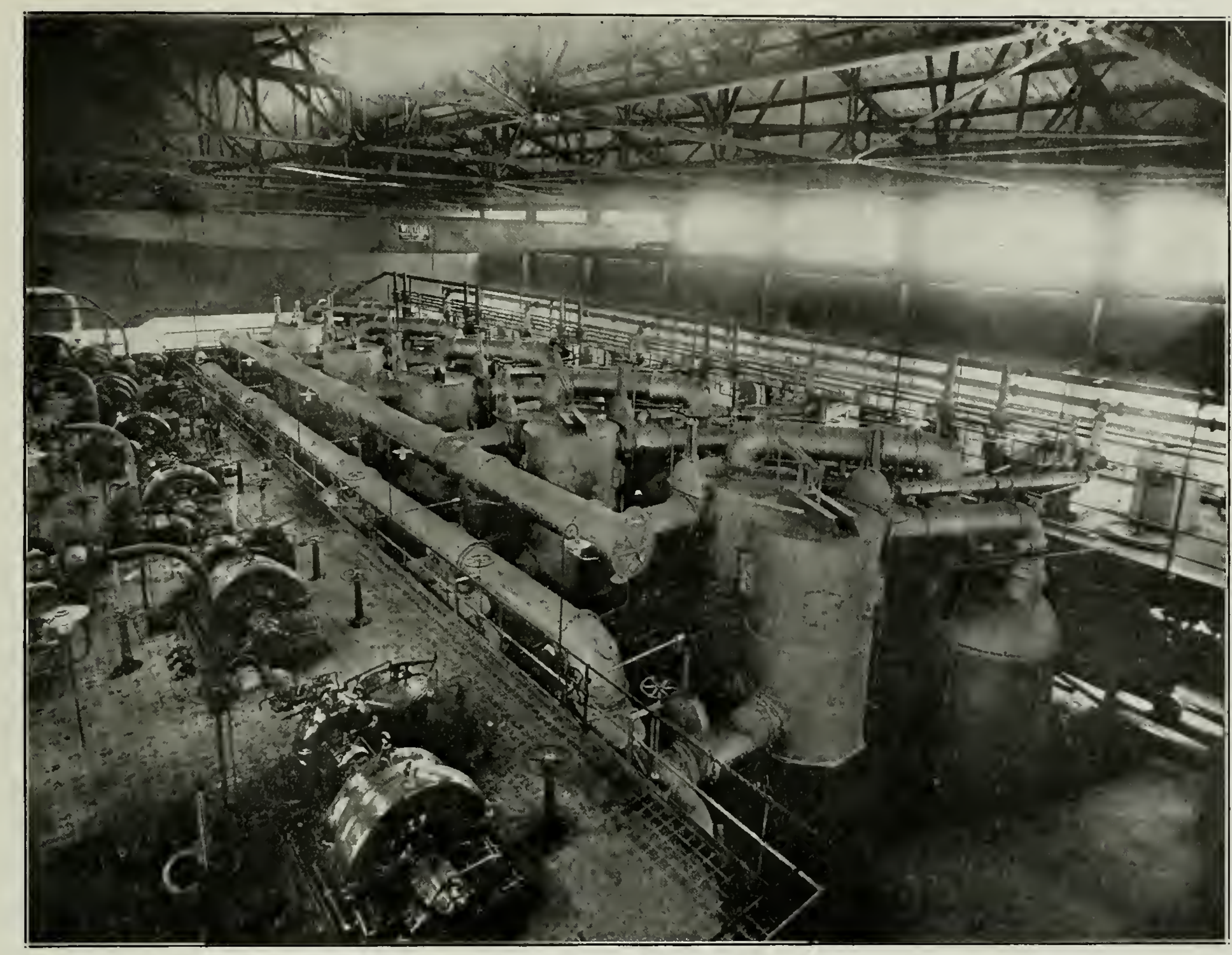

Fig. 9—Interior of by-product building, Franklin Plant, showing, left to right: Exhausters and boosters, tar extractors, acid separators, saturators and centrifugal driers.

diameter and averaging 36 feet deep. The caissons carry a series of 6-ft. square reinforced concrete beams and a concrete slab three feet thick upon which the normal coke oven foundations are erected. By this method the ovens are rendered entirely independent of soil conditions and any possibility of the blocks slipping down hill has been obviated. Several of the caissons run into abandoned mine galleries 30 or 40 feet below ground which caused additional difficulty, particularly in the case of those galleries which happened to contain water. All such difficulties were overcome, however, with entirely satisfactory results.

To provide working space in the center of the valley, it was necessary to construct a 16-ft. concrete culvert to carry Hinckston Run. This culvert is approximately 1,300 feet long, extending through the length of the plant.

In laying the foundations for the by-product building which in itself is built on three levels, particular difficulty was experienced due to the character of the soil at that point. Serious slides were a frequent occurrence, making necessary heavy retaining walls. In the completed by-product equipment, however, every advantage has been taken of the different levels so that gravity flow of liquors has been provided in many instances where ordinarily pumps would be required.

Possibly the greatest problems encountered at both the Rosedale and Franklin plants were those of material handling. There being no level space available at either plant, the storage warehouses were all erected at "Ten Acre," about a mile and a half below Rosedale. At that point, 17 buildings were erected with a total area under cover of 71,850 square feet, including brick sheds, cement sheds, steel and pipe warehouses and complete machine shops where a large part of the assembly details were carried out. All the material for both plants passed through "Ten Acre," about 11,000 carloads having been handled during the period of construction.

As now completed, the Cambria Steel Company possesses at its Rosedale and Franklin plants two of the most modern by-product coke oven plants to be found in the United States and the excellent results obtained in the first weeks of operation have already justified the heavy expenditure incurred. Mr. H. M. Crossett is general superintendent of both plants for the Cambria Steel Company, with Mr. J. W. McLaughlin as assistant in charge at Rosedale and Mr. E. Merrill as assistant in charge at Franklin. The construction work on both plants was directly under Mr. A. T. Leavitt, chief engineer for the Semet-Solvay Company, Mr. W. T. Snively and Mr. R. A. Foley being resident engineers in charge.

European By-Product Coking During 1921

The Year 1921 Has Been One of Great Anxiety and Depression as Far as the Coking Industry of Europe Is Concerned—No Startling Developments of a Technical Nature Are Reported.

By A. THAU
Coke Works Superintendent, Oxelösund in Sweden

IN ENGLAND hardly a single plant has operated up to its capacity and few companies had any or sufficient stocks of coal on hand to keep the ovens even warm enough to maintain an ignition temperature over the period of the coal strike. The most unfavorable conditions in the pig iron trade reflected further upon the coking industry and a large number of coking plants have been idle throughout the year, while the majority kept going with a reduced output.

The use of coke oven gas for domestic purposes has received a further serious setback owing to these conditions. There are comparatively few towns in England drawing gas from adjacent coking plants, the principal town depending upon coke ovens for its gas supply being Middlesborough. Pontypridd in South Wales also made arrangements to draw the greater part of its gas from the Maritime Coke Works, which are located nearby. This plant was enlarged for this purpose, but owing to the lack of coke orders the additional part of the plant could not be started and the gas works which deferred an enlargement of plant in the expectation of being supplied with coke oven gas are now in a precarious position.

The introduction of coke oven gas for domestic use has been greatly hampered in England because the coke oven owners were unable to give the necessary guarantees for an uninterrupted continuity of supply in case of strike or lack of coke trade. The municipal gas authorities maintain that, if they are compelled to keep up their gas plant at full capacity size and in good order solely for emergency, and in addition to this must keep huge stocks of coal on hand which naturally deteriorate or begin to burn, they might just as well keep the gas works going and do without the coke oven gas altogether. As long as this state of affairs exists, there is little hope for a more extensive use of coke oven gas for domestic purposes. The only gas works in England operating by-product coke ovens, viz., the City of Birmingham, has, owing to difficulties in disposing of the metallurgical coke, been compelled to discontinue the operation of the coke ovens during the latter part of the year. At the same time the sales of gas in Birmingham are 50,000,000 cubic feet per week lower, compared with the corresponding period of 1920.

Even though those batteries which were operated at all could not be worked to their full capacity, it is surprising to note that there are still a number of beehive oven plants in operation. It would be wrong to conclude that the old superstition of superiority of beehive coke compared with by-product coke is responsible for this, but it can be safely assumed that those collieries still operating behive ovens are depending upon their waste heat as a source of steam supply for their antiquated surface plant.

In view of the feared competition from the rapidly developing synthetic nitrate plants on the European Continent, great efforts are made to maintain a strong hold of the world's sulphate markets. The English sulphate of ammonia federation is continually urging its members to improve the quality of the sulphate by eliminating the free sulphuric acid which is responsible for the salt forming hard lumps and injuring the bags, while a sulphate with a given content of mositure is naturally correspondingly higher in nitrogen if by the absence of free acid a neutrality is procured. The English patent literature is full of inventions as to means for obtaining a neutral sulphate and a great number of supplementary plants have been erected recently with this end in view. The most simple and effective arrangement is to spray the sulphate immediately upon leaving the saturator with water diffused like a fog so that the moisture envelopes every crystal. Other inventors apply ammonia vapor from the still for operating the salt ejector. Others apply ammonia to the sulphate while being whizzed in the centrifugal dryer. Raw ammonia liquor, owing to its contents of pridine and naphthalene impurities, is not suitable for the purpose and discolors the sulphate. Another type of plant operates with two saturators in series, in the first one the salt drawn from the second is neutralized and the excess of ammonia escaping from the first saturator is fixed by the acid of the second. Finally it has been decided to leave the manufacturing process as it is and treat the sulphate afterwards with a proportionate addition of powdery slaked lime in a rotating kiln heated by gas, passing the escaping vapors through a seal of sulphuric acid to prevent a loss of ammonia. All these processes are being experimented with more or less on a trial basis and their great variety tends to conclude that no proper judgment as to the superiority of the one or the other can be passed until more uniform means of tackling the problem have come to stay.

While comparatively few English coking plants were formerly equipped to recover the benzol from the coke oven gas, the necessities of the war made the rapid addition of benzol recovery plant to all by-product works compulsory and it was surprising to note how quickly and successfully the chemical engineer of England adapted themselves to the new task because the few prewar plants in existence were almost exclusively of German origin. The rapid erection of so many benzol plants was accompanied by the repeated question, "What are we to do with all those benzol products after the war when the army and navy cease to be our main customers?" Three years of peace have shown that such fears were not justified and that the demand by far exceeds the production and would still do so even though all plants were working to full capacity. The

National Benzol Association, strongly supported by the English automobile associations, is endeavoring to make the recovery of benzol from coal gas compulsory by law even on gas works above a certain capacity.

The trial by Bury at the Skinningrove Iron Works, published immediately after the war, to recover the ethylene from the coke oven gas in form of alcohol in absorbing the ethylene in 6 deg. Be. sulphuric acid have not been realized on a commercial scale, although great expectations were expressed in responsible quarters. The heat economy of the process is so unsatisfactory that almost as many heat units must be spent as are recovered in the form of alcohol.

Low temperature carbonization, in spite of the formidable antagonism on the side of the gas works and coke oven engineers, has been stronger promoted and recommended than ever before, and the automobile associations who expect a plentiful motor fuel supply at moderate prices from this source, are backing the supporters with all their power. Still as long as the semicoke is not taken up industrially or as a household fuel on an extensive scale, there is little hope of the plants getting much further than beyond their trial basis where they have been for practically 20 years now. As already expressed in these columns by the writer, low temperature carbonization will as an isolated industry never develop much further; its expansion on a broad scale can only be expected if the iron and steel industry can see its way clear to adopt it as a supplementary side line such as coking plants.

Owing to the unsatisfactory trade of the industry in general, building operations on coking plants cannot be recorded. The few small additions to existing plants are hardly worth mentioning. Extensive repairs are being carried out on the idle plants so as to put them in a good state for restarting.

Germany.

The last year has been a conspicuous one for an overhauling of the coking plants which, driven to their utmost capacity during the war, were in great need of repairs. New walls in the ovens are being almost exclusively rebuilt of silica material.

Few contracts for new plants have been placed, which is not surprising owing to the unstability of the money and the continuous rapid depreciation of the paper money. It is quite impossible to get a binding quotation for large contracts and while a coking plant could be built before the war completely for a price approaching something like 8,000 marks per oven, this figure has since increased to 1,000,000 marks and the costs of even a moderate sized plant is in most cases quite out of proportion to the share capital of the company. The latter, however, is with most companies altogether out of proportion to the present money value and the value of the assets.

The German coking industry as a whole is in a singular condition in that most of the Rhenish-Westfalian plants are tied to the huge distribution center supplying an enormous district with domestic gas. The former gas works have been dismantled in these towns and consequently there are no emergency plants in case of the coke works giving out. In addition the peace treaty demands huge quantities of benzol and sulphate which must be delivered to France. On the other hand, the coke trade is slack and has necessarily followed the slump in the iron and steel trade. The result is that, irrespective of a very insignificant coke demand, the ovens must be kept going at full speed to produce gas, benzol and sulphate and consequently huge stocks of coke can be noticed to be accumulating at almost every coking plant, the coke pile often exceeds in size the adjacent refuse heap of the coal mine.

Before the war labor was very cheap and plentiful in Germany, comparatively, so that its charges did not show very much on the coke prices. The after-war conditions have brought about an entire change in this direction, mainly as a result of the compulsory eight-hour shift. While before the war the coke was treated by hand on a flat bench at a great majority of the plants, great efforts have since been made to introduce mechanical quenching and loading arrangements. In adapting them to existing local conditions, there are different devices on every plant for this purpose. The treatment of the coke by hand on a coke bench is disappearing rapidly now.

On the whole there is no appreciable difference between European and American coking practice except in the fact that as the American by-product coking practice is much younger it is more concentrated in large plants with larger units than in Europe where the plants in the majority are older and scattered about in smaller units. It would, however, be wrong to call them old fashioned or out of date. All new innovations are eagerly tried and if practical are introduced in all plants so as to increase the efficiency and economy of the plants.

The enormous coal supplies which the Versailles treaty extracts from Germany have naturally created an acute scarcity of fuel, and heat economy all around is necessarily the watchword. Skilled engineers have been engaged on every industrial plant and especially on coke works, which are being tested throughout as to their efficiency at repeated intervals and particularly to watch that no recoverable waste heat is allowed to escape unused. The introduction of these heat economists must be held responsible for extensive trials of many new innovations which a few years back were thought impracticable and which, although as yet in their trial state, are bound to come to stay in the next few years. In connection with this must be mentioned first of all the recovery of the incandescent heat of the coke leaving the ovens, which is now not used and destroyed by quenching with water. The cooling of the coke by inert gases not only enables the recovery of the heat, but at the same time improves the physical condition of the coke considerably. As futher means to improve the coke must be mentioned the elimination of ash from the coking coal by means of the froth flotation process, tried experimentally also in England by Bury and which was being accomplished at the same time on a commercial scale in Germany.

In the by-product plant innovations must be mentioned as new innovations, the introduction of electrically operated gas governors, though their first appearance dates some years back. They have now been considerably improved and generally introduced. The electro static precipitation of tar fog is undergoing extensive trials and the prevention of lime deposits in ammonia stills has been accomplished by a new plant. The absorption of the benzol hydrocarbons by means of a dry solid absorbent, viz., the so-called activated charcoal, is also being investigated on a commercial scale.

Prominent scientists are again eagerly engaged in finding means to utilize the sulphur contained in the coal gas as a binder for the ammonia, thereby eliminating the introduction of the expensive sulphuric acid. After the processes by Burkheiser and by Feld which many years ago made their appearance and were followed up with the closest interest, and which have not proved workable on a commercial scale, the problem is approached now from every possible direction.

While as yet the great majority by far of the existing coke plants—it will be understood that the last beehive or non-by-product coke oven has disappeared from Germany many years ago—are situated at the coal mines, there is now a great tendency apparent to place new coking plants on the same ground with the iron works in order to be able to utilize the surplus gas from the blast furnaces for heating the coke ovens and having the whole amount of coke oven gas available either for domestic purposes or for the steel plants. The coke ovens act then as heat transformers.

The application of coke ovens to gas works is highly developed on the European Continent. The majority of European capitals are operating coke ovens at their gas works which offer the advantage of being drawn and charged mostly on one shift only. To mention a few, Berlin, Vienna and Budapest are operating Koppers ovens; Munich has adopted the inclined coke oven by Ries; at the Haag are ovens by Klönne and at Kiel the Otto Company has very successfully introduced a battery of new recuperative ovens with vertical flues.

On the newly constructed coking plants in Europe, an extensive and ever increasing use of ferro concrete structures can be conspicuously noticed. Coal hoppers are almost exclusively built of this material as well as the side structures of the ovens for machine tracks. In addition concrete tanks for tar, liquor and oils come more and more into favor wherever a plant is built on ground free from subsidences. Concrete tanks offer the advantage of resisting corrosion much better than iron or steel plates.

Although low temperature carbonization was practically unknown in Germany before the war, it has been taken up as a side line experimentally by the iron and steel industry and several plants on a commercial scale are under erection and will be started early next year, the results of which are awaited with interest.

Belgium.

The Belgian coking industry has soon rallied to prewar capacity and while little constructional work has been carried out, the plant which was being built in 1914 at Vilvorde (a suburb of Brussels) by the Semet-Solvay Company and stopped by the outbreak of the war has been completed and started early in 1921. It consists of two batteries of 38 regenerator ovens each, from which the gas is taken off in two fractions, of which the first helps to supply the City of Brussels with domestic gas. While the coal mined in Belgium is rather lean for coking, it was formerly mixed with a corresponding amount of English coal high in volatile matter before charging it into the coke ovens. These coals being too expensive now, German coals from the compulsory deliveries of the peace treaty are used in their stead.

France.

While a number of coking plants in France have been destroyed by the war, the total coking capacity has been increased by the acquisition of the Lorraine and Saar districts. These southern coals are as a rule of poor coking quality and must be compressed before charging them as otherwise they will not bind to coke at all. While these industrial centers were under German control, the rather brittle coke was generally mixed with coke from the Ruhr district which is of much superior quality. The absence of this coke has been keenly felt after the war at the Lorraine and Luxemburg works so that special efforts are being made to improve if possible the coke from the Saar district. New ways to obtain a satisfactory industrial coke from these coals are said to have been discovered by trials, but no details have been published so far. The coking plants in the devastated areas are to be rebuilt together with the mines, but some time will elapse yet before construction can be commenced.

Conclusion.

While this gives an outline of the main coking centers of Europe, a few coking quarters of minor importance have been omitted, particularly the coal field covered by Silesia, Austria, Poland and Czecho Slovenia have not been mentioned. The political sky in that region has been so much in prominence and so totally clouded everything else during the whole of last year that the conditions of the coking industry remained enveloped for the writer.

A modernly equipped coking plant should be mentioned operating 120 regenerator ovens by Hinselmann at the government mine Emma in Holland and making so excellent a coke that it is not affected by any fluctuations of the coke market.

A single coke oven plant consisting of 60 Koppers regenerator ovens at the Oxelösund's iron works in Sweden operating upon Pocahontas and West Virginia coals from America under the writer's supervision was shut down altogether early in 1921; it being impossible in Sweden to compete against the prices for coke imported from England and pig iron from Luxemburg, owing to the unfavorable rate of exchange.

In summarizing, one can safely assume that after the involuntary impediment in the development of the coking industry on account of the war, new progress is to be expected in the coming year. The new innovations mentioned in this report are also known in the by-product coke industry of America. The froth flotation of coal has been frequently treated in American scientific journals; the cooling of incandescent coke by inert gases has been described by the writer recently in the *Iron Trades Review*. The electrostatic precipitation of tar fog is not sufficiently advanced yet to be able to report practical results. The construction of electrically operated gas governors and of a plant preventing the lime from depositing in ammonia stills will form the subject of two further articles by the writer in these columns.

ACCIDENTS IN THE STEEL INDUSTRY.

The total steel mill accident rate, per 10,000,000 hours worked, has fallen in America 55 per cent since 1907, and the fatal accident rate has fallen more than 70 per cent, as shown by figures of the Department of Labor. The figures given for 1907, per 10,000,000 hours worked, show 7 deaths, 13 cases of permanent disability, 788 cases of temporary disability and a total of 808 cases. For 1920 these figures were 2 deaths, 9 permanent disability, 357 temporary disability and 368 cases in all. Severity rates fell in about the same proportion as frequency rates. Figures for 1907 showed an average of 72 days lost for each 10,000 hours of exposure. In 1920 the loss was only 27 days. All departments, save the electrical, shared in this gain, the open hearth and blast furnace plants showing the greatest decreases, and needing to do so, for their rates in 1907 were more than double the average of the other departments.

By-Product Coke Oven Industry in 1921

The Feature of This Year in the By-Product Coke Industry Has Been the Numerous New Ideas Developed in Relation to By-Product Coke Oven Practice.

By C. J. RAMSBURG
Vice President, The Koppers Company

A RESUME of the By-Product Coke Industry in 1921 indicates that there have been fewer ovens built during this year than in any year since 1914. This is largely due to the general business depression which has been prevalent throughout the country. According to the best information obtainable, the following ovens were completed during 1921:

Company	Location	No. of Ovens	Type of Ovens
Chicago By-Product Coke Co.,	Chicago, Ill.	100	Koppers
Camden Coke Company	Camden, N. J.	37	Koppers
Dominion Iron & Steel Co.,	Sydney, N. S.	60	Koppers
Milwaukee Coke & Gas Co.,	Milwaukee, Wis.	50	Koppers
American Coke & Chemical Co.,	Granite City, Ill.	80	Roberts
Cambria Steel Company	Johnstown	80	Semet-Solvay

Great Progress Made.

Although less construction work has been done, there has been great progress made in this industry during the past year by the development of new ideas in relation to by-product coke oven practice.

Underfiring Ovens with Producer Gas.

One great improvement has been the increased substitution of producer gas for underfiring coke ovens. At the plant of the Seaboard By-Product Coke Company, Jersey City, N. J., 6 Koppers-Kerpely Producers have been built, which furnish producer gas for underfiring 110 Koppers Combination Ovens. There has also been completed and put into operation a battery of 37 Koppers Combination Ovens for the Camden Coke Company at Camden, N. J., together with 4 Koppers-Kerpely Producers, which furnish gas for underfiring these ovens.

As in normal modern by-product coke oven practice, from 30 to 40 per cent of the total gas recovered in coking is returned to the ovens for underfiring, the importance of this development can scarcely be overestimated.

A few operating figures may be of interest in this connection:

Approximate amount of gas produced per ton of coke used in producers—150,000 cu. ft.

Average heating value of gas—129 Btu. per cu. ft.

Average analysis of gas:

CO_2	2.5%
O_2	0.5%
CO	30.0%
H_2	10.0%
CH_4	1.5%
N_2	54.5%

Coke required per M. ft. of coke oven gas released—55.4 lbs.

Coke oven gas released per ton of coke used in producers—36,100 cu. ft.

A brief description of the producers erected at these two plants may be of interest as they are the first installations of this type of producer in this country. They are designed to use the small size coke, between blast furnace sizes and breeze, and each producer has a capacity for gasifying approximately 30 tons per day. The producers are of the revolving grate type with stationary water cooled shell built up as a low pressure boiler, which generates sufficient steam for the operation of the producers. The producer plant is also equipped with high pressure waste heat boilers, which furnish more than sufficient steam for the operation of the producer gas cleaning plant and gas boosters. The entire producer plant installation is of very rugged construction and equipped with all labor saving devices, which tend to reduce operating costs to a minimum.

Narrower and Higher Ovens.

Another feature of the year has been the completion and beginning of operation of plants consisting of the narrower and higher type of ovens. In the older type of Koppers oven, the height of coal mass has generally been approximately 8 ft. 10 in., whereas in the newer type of oven now in operation at Chicago, the coal mass has a height of 11 ft. These ovens have an average width of only 15½ in. It is now well established that the higher and narrower oven will give the best operating results.

Liquid Purification.

Another interesting feature of the year has been the development by the Research Department of The Koppers Company of a new method of purifying gas. The limited space available here does not permit a description of this process, but it has been well established in actual operation that the cost of purifying gas by this method is less than half the cost under the dry oxide purification method, with equally good results. This new, simple and inexpensive method of removing hydrogen sulphide from the gas will probably prove to be of great value to the steel industry.

New Construction.

There is very little new construction going on at the present time. The only ovens now being built are the remaining 100 Koppers ovens for the Milwaukee Coke & Gas Company at Milwaukee, Wisconsin, and the rebuilding of 30 ovens for the Woodward Iron Company at Woodward, Alabama, which is being done by The Koppers Company.

Summary.

On the whole, the By-Products Coke Oven Industry has come through the trying times of the past year in very good shape. The value of operating by-product coke plants in connection with the iron and steel plant has never been more conclusively shown, for, due to the great flexibility possible in by-product coke oven operation, it was a simple matter to adjust this to meet the varying demands of the steel plants for coke and gas.

One deterrent feature has been the subject of freight rates. In many cases the existing rates have proven discriminatory in favor of the beehive coke. However, negotiations are now under way looking toward the adjustment of these rates, and it is believed that when this is accomplished it will have a favorable reaction on the By-Product Coke Oven Industry.

Recent Development in Steel Mill Cranes

Modern Improvements in Cranes Have Been Dictated Largely by Three Aims, Safety, Accessibility and Standardization.

By GORDON FOX*

DURING the war period there was not a marked improvement in crane design and construction. The heavy demand together with the requirement for quick delivery resulted in cranes built largely to "manufacturers' specifications" and therefore largely duplicating previous practice. With the present competition the manufacturers are alert and receptive to the purchasers' desires. The present situation is therefore favorable to improvement.

Probably the most important recent development is the adoption by the Association of Iron and Steel Electrical Engineers at their Chicago convention of a standard code of specifications. This code is sufficiently liberal to warrant its general adoption, yet sufficiently specific to result in standardization along the lines of the "mill type" crane. This code will no doubt become more or less entrenched through its influence on state regulations.

Recent improvements in cranes have been dictated largely by three aims, viz., safety, accessibility and standardization. The trend is decidedly toward the inclusion of all reasonable safety features. More spacious cabs are provided to house magnetic control without unsafe crowding. Cabs of hot metal cranes are fireproofed and exits carefully provided. Wiring is more thoroughly enclosed in conduit and safety switches with locks employed. Limit switches are becoming quite universal although not always of satisfactory type. Gears are entirely covered and shafts and couplings are protected. Liberal walks with toe boards are more common and shields or plates are being put beneath parts which are liable to become loose and fall. These are but a few examples of the general trend.

Accessibility is being demanded in order that repairs may be more rapidly, safely and cheaply made. The older designs, more or less inaccessible, are becoming less acceptable. Attention is being directed to render the oiling of cranes more convenient so that it may be more safely and certainly performed. Provision is made on some cranes or their runways to afford better access to the end trucks and in a few instances platforms have been provided under the trolley to prevent the need of slings and scaffolds in reaching sheaves or other parts. "Fiddle string" trolley wires are now almost entirely eliminated, being replaced by bars or angles and located above the bridge girder which are more easily accessible for cleaning or other repair.

The adoption of the A. I. S. E. E. code will further the cause of standardization through the adoption of standard shafting, couplings, gears, wheels and other parts. The significance of standardization is tremendous, particularly in the larger plants.

Of interest electrically is the almost universal use of dynamic braking with direct current hoist motors and the more frequent realization of the possibilities of adjustment for independent hoisting and lowering speeds. A new brake has been developed for hoist duty on alternating current cranes. This brake is designed to afford adjustable braking torque in lowering in addition to holding a fixed load. This brake makes possible the elimination of the mechanical load brake on alterating current cranes.

A few cranes have recently been constructed using ball or roller bearings, at least in part. It would seem that this type of bearing must establish superiority by decreasing maintenance rather than by reducing friction. The greater portion of a hoisting load is useful work. Much the greater portion of trolley and bridge loads are due to inertia. Flange friction is a more serious offender than bearing friction. The advantages of reduced bearing friction do not appear of pre-eminent importance.

There has been developed for the locomotive shop a four girder four trolley crane or a combination of two two girder, double trolley cranes arranged to permit hoisting the locomotive between the girders. This decreases the headroom and lowers the building cost. It also permits these cranes to be located on a lower runway, nearer the work.

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*Mr. Fox is electrical engineer for the Freyn, Brassert & Company, Chicago, Ill.

COMPANY TRIES TO ENLARGE HOLDING

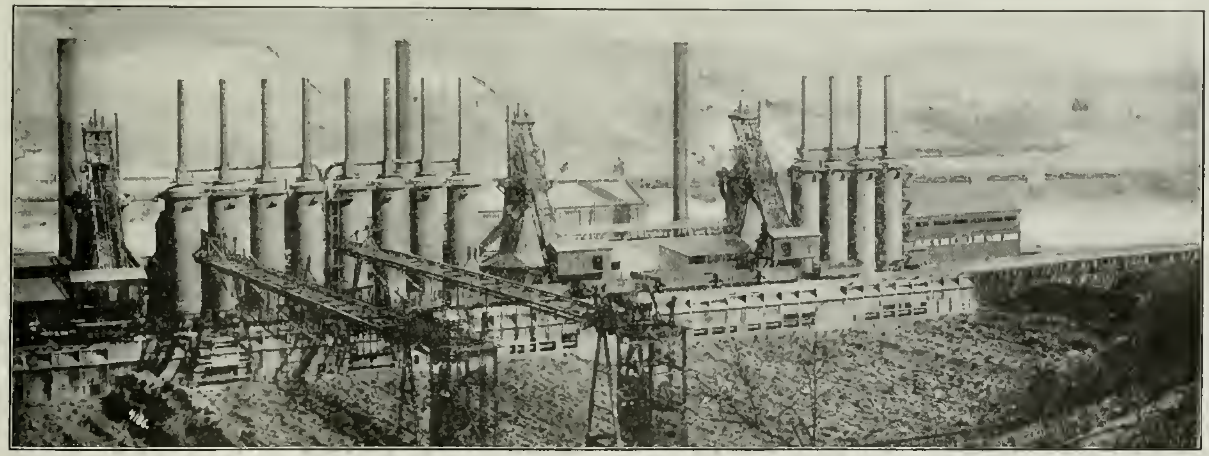
The American Rolling Mill Company, Middletown, Ohio, has made a definite proposition for the purchase of the assets of the Ashland Iron & Mining Company, Ashland, Ky. Should the deal go through, the American Rolling Mill Company will acquire two blast furnaces with a capacity of 100,000 tons of pig iron yearly; a practically new open hearth department, consisting of six 100-ton furnaces; a very modern blooming mill and six sheet mills.

Blast Furnace Department

Interesting Sintering Plant at Birdsboro, Pa.
By B. G. KLUGH

Hot Blast Stove Rating
By F. H. WILCOX

New Blast Furnace at McKeesport
By DONALD N. WATKINS



Interesting Sintering Plant at Birdsboro, Pa.

Description of the Sintering Plant Built for the E. & G. Brooke Iron Company at Birdsboro, Pa.—Reclamation of Long Abandoned Iron Mine by Means of This Process.

By B. G. KLUGH*

THE new sintering plant of the E. & G. Brooke Iron Company at their Birdsboro, Pa., works is of interest from several standpoints. It functions in conserving and utilizing the iron ore resources, embodies the highest development of sintering plant engineering to date, and features an example of highly successful outgrowth of the entire historic background of sintering iron bearing materials.

It is of unique interest to preface the technical description of this plant with a brief recital of its forerunners.

The first plant to operate on the down draft blast roast treatment of iron bearing materials was built at this works in 1911. Although of rather crude design inherent to initial installation, it operated quite successfully from the start, treating flue dust, both the current production and that of the stock pile, the latter being an accumulation of flue dust from the period of anthracite fuel to that time.

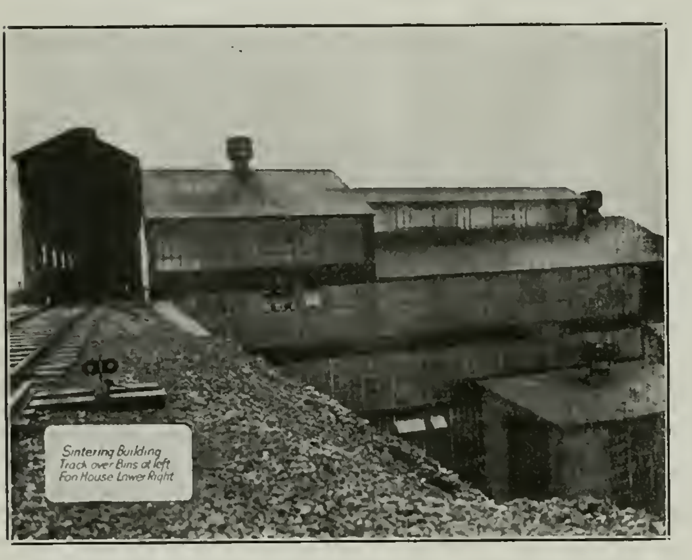


Fig. 1.

This plant was built and operated by the American Ore Reclamation Company on a conversion agreement with the E. & G. Brooke Iron Company. Although this first plant was naturally of rather crude design and construction, it was operated profitably until the entire stock pile was consumed and the furnace plant closed down for relining in September, 1912.

Operations were resumed in February, 1913. The plant was then operated on current flue dust from the E. & G. Brooke Iron Company's furnaces and on flue dust purchased from other furnaces in the district.

With the depletion of the flue dust stock pile, the necessity of finding other materials that might be profitably treated in this plant arose. The fact that the process simultaneously desulphurizes and sinters materials efficiently, had been established in numerous tests on this plant. The desulphurization of the French Creek ore bed had been anticipated as a possibility from the inception of this sintering plant.

The French Creek mines owned by the Brooke interests are located in Chester County about 10 miles from Birdsboro. Ore had been taken from this deposit dating back to Revolutionary days, and this specific mine was operated spasmodically for many years, with attempts at smelting the ore both raw and with various roasting processes. The high sulphur and great variation in lime content prevented their successful use, and although it was known that a large body of the ore existed, the results of their smelting had been so discouraging that they were abandoned in 1896. A further attempt to use this ore by preroasting in Gjers kilns was made in 1898, but after a year's trial the mine was closed and considered permanently abandoned. During the interim, foreign and Lake Superior ores were used in the Brooke furnaces.

Tests showed that by crushing French Creek ore to ¼-in. size and sintering with about 3½ per cent carbon, the sulphur could be eliminated down to under 0.1 per cent. Furthermore, the fine crushing permitted the obtaining of a uniform mixture, eliminating the variation that existed in run-of-mine lump ores. An additional advantage obviously lay in the fact that while the dense lump magnetite presented very limited area of contact to the action of the reducing gases in the furnace, resulting principally in hearth reduction, high fuel consumption and low furnace production, the sintered product, consisting of cellular structure, presents great area of contact to the gases, with uniform resistance over the entire section of the stock column, obviating the inherently objectionable features to smelting massive magnetites.

With this in view, sufficient ore was taken from a stock pile that had lain at the French Creek mine for several years to make a sintering and furnace test on the French Creek ore.

The results were so satisfactory that the small sintering plant was taken over by the E. & G. Brooke Iron Company, and a crushing plant built to operate in conjunction with the sintering plant, for the treatment of their French Creek ore.

A number of improvements were made on the original plant, in the way of improved handling equipment, larger fans, better ignition equipment, larger and better pugmill construction, etc. The Brooke people further made large investments toward reopening their mines and providing modern mining equipment. The development of these mines naturally required considerable time to attain an economical output.

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*The author is secretary of the American Ore Reclamation Company.

The operation of this sintering plant, known as plant No. 1, was continued until April, 1919, during which period it produced over 200,000 gross tons of sinter.

The results obtained from the small plant were so satisfactory that it was determined to build a larger plant to meet the demand for a greater tonnage. This larger plant, known as plant No. 2, was started February 21, 1919.

This installation consisted of one American Ore Reclamation Company 42 in. by 57 ft. 4 in. machine of 200 square feet hearth area, with proportionate auxiliary equipment. The building was of wood construction and adjacent to the old sintering plant, so as to utilize the existing crushing plant. The new large plant was operated very successfully until totally destroyed with the crushing plant on May 5, 1920, after producing about 100,000 tons of sinter.

Notwithstanding the heavy loss sustained by this fire, the E. & G. Brooke Iron Company decided to build a larger and more modern plant immediately. This included a new and modern crushing plant, in conjunction with the sintering plant, the description of which forms the basis of this article.

The crushing plant deserves a special article for its description, hence will not be described here. Its design and construction by Messrs. W. B. Devereux, Jr., of Wilkins & Devereux, 120 Broadway, New York City, and M. T. Hoster, manager of mines, for the company, embodies the latest development in crushing, screening and handling equipment. The crushers and rolls in this plant were designed by the C. G. Buchanan Company and built by the Birdsboro Steel Foundry and Machine Company.

The run of mine ore is delivered from standard gauge cars into a track hopper, and from there by a series of continuous steps, the material is screened and crushed automatically, and the product of minus $\frac{3}{8}$-in. crushed ore is delivered by means of an inclined conveyor onto a shuttle belt, which distributes it among the sintering plant bins.

Storage Equipment.

There are 8 bins, arranged in a straight line, each of 200 tons capacity and of circular section. The tops of the bins are covered with cast iron grating, with 2-in. square openings, all continuous. A standard gauge track is provided over the two end bins for discharging flue dust, fine sintering fuel, return fines or other materials directly thereinto. The entire bin equipment is housed in a steel building arranged at a right angle to the sintering building proper. This covering extends over the top of the bins with ample head room to admit a locomotive to run thereinto.

Feeding and Proportioning Equipment.

Each bin is served at its bottom with a revolving disc feeder of the American Ore Reclamation Company design. The feeders are in principle the same as that in many other sintering plants, with the exception of the drive. This drive consists of a worm gear mounted on main drive shaft. The latter shaft runs the full length of the bins, and each worm is independently provided with a jaw clutch by which any one of the feeders may be thrown in or out of service without disturbing the others.

This arrangement makes it possible to eliminate the double reduction used where bevel and spur gear drives are used, and provides simplicity in that only one shaft, through the line of bins is necessary. Notwithstanding the rather wide objection to worm drives, this was installed, using a very heavy cast iron worm and gear. The plant has been in operation for some time and no signs of under wear on the slow moving, positive, and non-vibrant drive have appeared. This type of feeder embodying a positive volumetic feeding device was originally developed by the American Ore Reclamation Company and is in use in 15 plants, including the recently described plant of the Cambria Steel Company. Slight differences in the details of the method of driving this feeder exist in the various plants.

Collecting Belt.

All of the eight feeders discharge onto a 30-in. belt conveyor which is located parallel to the line of feeders. The conveying side of the belt is arranged under the discharge edge of the feeder discs, so that no spouts or skirt boards are required to prevent spillage. The material as delivered from the several feeders onto the belt forms a continuous stratified layer, which is maintained in a uniformly proportionate mixture as discharged from the belt.

Bucket Elevator.

The collecting belt discharges into the boot of a belt bucket elevator, consisting of a 20-in heavy rubber belt with 18-in. style B malleable iron buckets, spaced about 18 inches apart. The elevator is wholly enclosed in steel plate casing and slightly inclined. The upgoing strand is provided with supporting idler pulleys, having bearings and lubrication outside the casing. The elevator runs at a speed of 250 rpm. The performance is highly satisfactory, having no objectional spillage or tendency to clogging.

Distribution of Elevator Discharge.

Provision is made for distribution of the sintering mixture, as discharged from the head of the elevator, to two sintering machines. This consists of a mechanically operated oscillating cutter gate, in the discharge spout of the elevator, which divides the stream into two parts, each being delivered through two sections of a bifurcated spout onto respective inclined conveyors. The two conveyors are each about 6 ft. 6 in. centers, and are 24 in. wide, and discharge directly into the pugmills.

Pugmills.

The pugmill is of the latest cast iron body, double shaft type, having been designed in all details by the engineering department of the American Ore Reclamation Company. It is practically a duplicate of those in the new sintering plant of the Cambria Steel Company, as well as in other new plants. It was built by the Duncan Foundry & Machine Company of Alton, Ill. The cast iron body, connecting the two heads rigidly, prevents the vibration which was found objectionable in the older steel plate types of pugmills.

This quiet running mixing element performs its function of continuous mixing, moistening, and conveying almost ideally.

Sintering Machine.

This machine is of the standard American Ore Reclamation Company type B 42 in. by 57 ft. 4 in. design. Although the plant is laid out and all auxiliary equipment constructed for two machines, only one was installed for the present.

No hearth layer is provided, as the material treated, being coarse in size and requiring only about 3½ per cent of its weight of sintering fuel, gives no hard service to the grates.

The sintering mixture, after being properly moistened and uniformly mixed in the pugmill, passes directly therefrom and is uniformly distributed across the section of the pallets, by means of a swinging spout. This spout is operated from the sintering machine drive so that its stroke synchronizes with the speed of the machine.

The sintering product is discharged automatically from the pallets onto a stationary grizzly, and into standard gauge railway cars. The fines or "returns" drop through the grizzly spaces into a standard gauge railway car, which return it to the storage bins for retreatment.

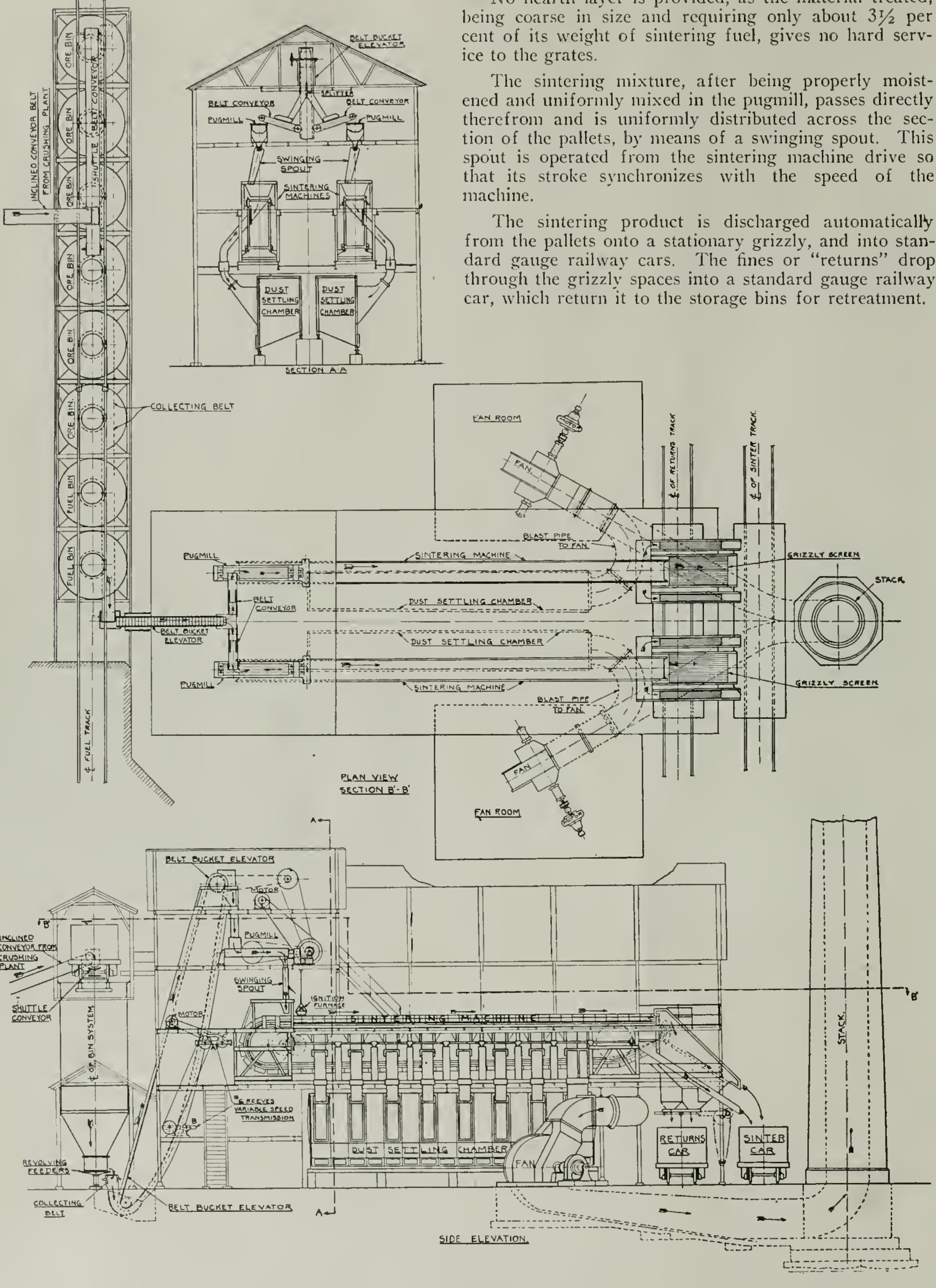
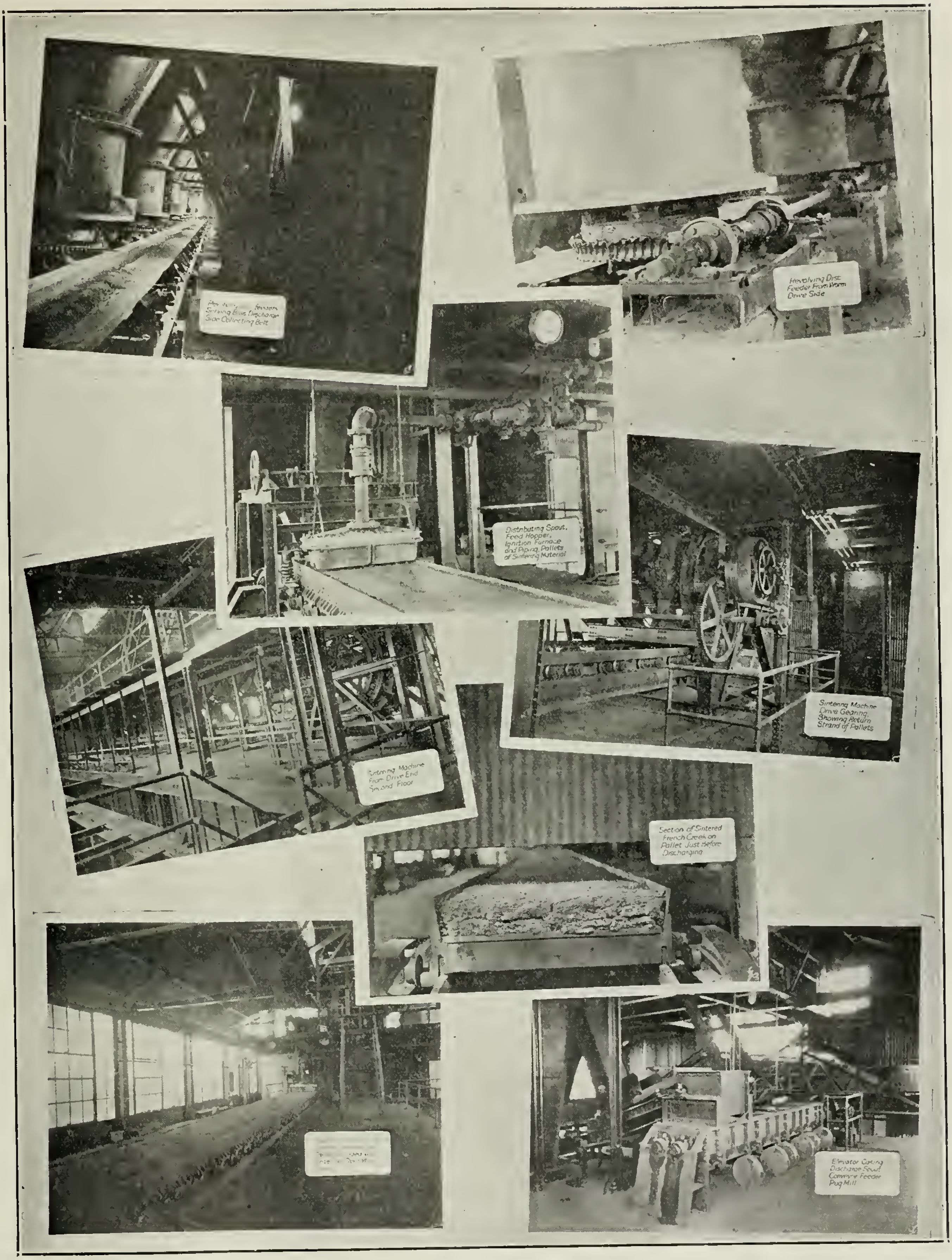


Fig. 2—General Plan of Sintering Plant.



Ignition System.

The initial ignition is performed with illuminating gas, but provision is made for the use of blast furnace gas when the furnace is in blast. The piping is so arranged that illuminating gas may be momentarily turned on during short periods of interruption of supply of blast furnace gas. This may be accomplished by opening and closing of valves with no interruption of the continuous sintering operations. The standard A. O. R. Co. type of ignition furnace is used, which performs equally well on any gas or oil ignition, and gives a uniform controllable ignition of exactly the required intensity.

Suction System.

Each of the nine windbox pipes is connected into a large cast iron dust collector, which is located below the sintering machine floor and parallel with the machine.

This dust collector is of a larger size than is usually constructed, and provides ample volume for settling out substantially all of the dust which drops through the grates or is entrained with the exhaust gases.

This dust collecting chamber is provided with a sloping side, and continuous cleaning doors, so as to empty the dust collected therefrom in least possible time.

The gases are taken from this chamber at the discharge end of the machine, being conducted through a 5-ft. diameter main directly into a 100 diameter fan of the new sintering design. The fan is of the center plate wheel, double inlet type, and has a capacity of 60,000 c.f.m. when working under 20-ft. w.g. suction. It was furnished by the American Blower Company of Detroit, Mich. The bearings are of double sleeve, water cooled, spherical self-aligning type. The fan is directly connected through a flexible coupling to a 350-hp. induction motor.

The gases from the fan pass through an underground flue and out through a brick stack 7 ft. 6 in. diameter by 160 ft. high. The high stack is necessary to prevent the sulphur bearing gases from the desulphurization of the ore from settling in objectionably concentrated form in the immediately surrounding vicinity.

Synchronous Drive and Control.

The automatic control of synchronizing the volume of material fed to the demands of the sintering machine and simultaneously and independently controlling the proportions of the various materials in the sintering mixture, is accomplished positively and accurately. A 30-hp. motor drives a No. 6 Reeves variable speed controller "A." This Reeves "A" drives the sintering machine through its variable speed shaft, which also drives a second No. 6 Reeves controller "B," which through its variable speed shaft drives the feeders and collecting belt. In this way any change in the speed of the sintering machine, by adjustment on controller "A," produces a corresponding change of speed of the feeders. On the other hand, if it is desired to change the volume of material being delivered by the feeders to meet differences in the demands of the sintering machine, this is accomplished independently of the sintering machine speed by adjustment of controller "B." After such adjustment, the synchronism of the speed of the feeders (and resulting volume fed) will continue to be automatically controlled by any changes in the sintering machine speed by adjustment on controller "A." The proportion of the various materials fed from any or all of the eight bins is regulated by means of independent gates on each of the feeders.

The controls governing the synchronizing of the above factors, as well as that of the moistening, ignition, depth of charge, etc., are very handily arranged on the operating floor, so that one operator has quick control of all factors, and observation from a single point.

Special Features.

The simplicity and accessibility of all mechanical elements, including drives, gearing, and all moving parts, is especially notable in this entire plant.

The extremely small number of moving parts in this plant, with the achievement of every degree of desired flexibility, and at the same time of large production and smooth operation, with its comparative absence of dust and noise, makes it a pleasing demonstration of the development of the art.

The very small operating force required is a predominant feature. The illumination of the plant is very uniquely and effectively executed. The liberal use of frosted wire glass sash on the building sides gives ample light to all parts in daylight, and flood lights arranged at the end of the building illuminate the operating floors completely and without undue glare or shadows.

The construction is of structural steel, with plate floors throughout.

The fan rooms are of brick, practically dust tight construction, and are arranged adjacent to the sintering building, thus eliminating unnecessary length of blast piping.

Performance.

This plant has for its primary function the benefaction of the French Creek ore, which as before stated is practically valueless in its raw state as a blast furnace material. At the present time high carbon flue dust is being used as a source of sintering fuel, thereby reclaiming the iron values of the flue dust simultaneously with the desulphurizing and beneficiating the ore. This flue dust is obtained from the E. & G. Brooke Iron Company's own furnace as well as that from neighboring furnace plants. A typical analysis of the French Creek ore and the sintered product is as follows:

	Raw French Creek Ore	*Sintered French Creek Ore*
Fe	52.70	54.80
SiO_2	11.50	12.90
Al_2O_3	2.10	2.50
CaO	1.70	2.30
Sul	2.60	.10
P	.040	.050
Mn	.15	.21

The capacity of this plant with the single machine is 500 tons per day, and with the second machine 1,000 tons per day.

Personnel.

The executive credit of this entire development is largely due to Mr. Robert E. Brooke, under whose business direction all the enterprises involved, from the small plant in 1911 up to the present stage, have been conducted.

The construction work was done under contract of Hughes, Foulkrod & Company, Pittsburgh.

The engineering and design was performed in collaboration and consultation with the American Ore Reclamation Company.

Hot Blast Stove Rating

Actual Test Data Showing the Effectiveness of Hot Blast Stove Equipment as Applied to a 600-Ton Blast Furnace.

By F. H. WILLCOX*

ANY reasonable expense that leads to measurable worth while economy in blast furnace plant operation is justifiable in the construction or rehabilitation of the plant. The factors that make for economy are large tonnage of good quality iron, low fuel consumption, low cost of handling materials and ability to consummate sales and purchases to advantage. It is not infrequently overlooked that a blast furnace plant is not built to make pig iron but is, or should be, built to make money. Therefore, expense in equipment or construction which looks toward a betterment in the rating of any of the above four factors must, or should be, undertaken only upon the basis of evidence which will support the contention or belief that certain improvements will sufficiently reduce certain items of pig iron cost to enable a plant to meet the market with a materially better margin between cost and sales price.

A policy of parsimony in the fittings of a furnace plant is rarely conducive to the satisfactory realization of any of the first three of the factors cited above. On the other hand, prodigality in the fittings of the plant stands an even greater presumption of inability of costs meeting the market. In this case, unwarranted expenditures have been committed in an endeavor to reduce the force to a number actually below the number of men reasonably required, not for operation but for the not infrequent contingencies and emergencies that arise. Consequently it is not safe to avail onesself of the possible reduction contemplated in the planning of the plant. Or similarly ill considered expenditures are made to secure the last increment in increase of efficiency of pumps, hoists, blowers, boilers, generators and similar items of equipment. Consequently the fixed charges against a kilowatt, or boiler horse power, or 1000 gallons of water, cause the total cost to be actually in excess of the cost of equivalents from considerably less efficient equipment. Quite obviously, similar contrasts may be brought out in the design and fittings throughout any plant.

Quantity production of good iron with low fuel consumption reverts to management—materials and equipment being equal. Given good coke, good furnace lines and good management, the coke consumption will depend upon the heating capacity of the stoves. It is quite unnecessary to speculate any more about how much heat a set of hot blast stoves should be able to impart to the blast. For furnace lines as developed today, for ore allotment received from the lake region, and for quality of coke approximately indicated for the vast majority of operations, a set of hot blast stoves should be able to continuously carry 1250 deg. F. straight line heat, with a margin of heat reserve. Of course the heat actually to be carried cannot be predicted. The only fact actually available is that good stove practice is to carry as much heat as good furnace practice will allow, or if the furnace takes the heat good, to burden the furnace as heavily as possible on as high a blast temperature as it is possible to uniformly hold, with maintenance of reserve heat for emergencies.

Singularly enough, it is a fact that those plants doing outstanding work are not at all necessarily those carrying the highest stove heats, and this leads to a continual misapprehension of the value of large stove capacity. However, a determination of the facts shows that in the greater number of cases those plants having the best heat equipment have the best coke consumption. In cases where this is not true there is trouble with quality of coke or distribution. Even where plants with good heat equipment show good coke practice, the effectiveness of the equipment is not at all necessarily disclosed by the average heat carried. Quite frequently they run on moderate or moderately high heats only, high heats being used but a small fraction of the time. The writer has experienced more than one instance where after expenditures have been made for gas cleaning and increased heat equipment, and where the coke consumption had been reduced even radically, it was difficult to attribute the gains to the expenditures simply because the very moderate increase in average blast temperature was entirely out of line with the saving in coke effected. Rather naturally the impression is gained that considerable expenditures have been made and little advantage gained in heat. Of course, as a matter of fact, the increased heat reserve, some days not employed at all—other days desperately required and available, has actually effected the betterment. For perhaps the majority of operations the above practice is the most practical method of utilization of good heat equipment. Plants long equipped with good heat equipment are as a rule those working along the line of a gradual increase in average temperature of blast. Other factors, however, have to be brought into line with this tendency.

One may say, therefore, that expenditures put into good heat equipment are paying. Considering that entirely adequate and good hot blast stoves for a new plant cost less than ten per cent of the cost of the plant, it is clear that provision of absolutely full measure of heat equipment is a phase of planning and construction where tonnage and quality of iron as well as low coke consumption are quite largely determined. Liberality in stove equipment is an insurance at no considerable increase in plant cost. The day of extravagance in construction is certainly gone for some time to come. Therefore, the equipment must be put in with some degree of precision.

This tabulation is an analysis of the effectiveness of hot blast stove equipment commonly put in for furnaces designed for 500-600 tons of pig iron per day. For maximum load conditions, the higher tonnage is taken as a base.

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*Mr. Willcox is secretary of the Freyn, Brassert & Company, Chicago, Ill.

EFFECTIVENESS OF HOT BLAST STOVE EQUIPMENT.

600-Ton Furnace Basis—44,000 cu. ft. wind per min.

Stoves 22 ft. diameter by 100 ft. high. Two-pass, side combustion.

1.	Size Checkers	3½ x3½″	4 x 4″	4½ x 4½″	5¼ x 5¼″	6 x 6″
2.	Thickness of Brick	2″	2½″	2½″	3″	3″
3.	Checker Openings	1000	715	616	445	373
4.	Area Checker Openings	85 sq. ft.	79 sq. ft.	87 sq. ft.	85 sq. ft.	94 sq. ft.
5.	Heating Surface in Checkers	93,400 sq. ft.	76,200 sq. ft.	73,900 sq. ft.	62,200 sq. ft.	59,800 sq. ft.
6.	Cu. ft. Brickwork in Checkers	10,000 cu. ft.	10,400 cu. ft.	9,850 cu.ft.	10,000 cu. ft.	9,300 cu. ft.
7.	Weight Brickwork in Checkers	1,280,000 lb.	1,335,000 lb.	1,265,000 lb.	1,280,000 lb.	1,195,000 lb.
8.	Ratio Heating Surface to Cubic Contents	9.34	7.34	7.50	6.22	6.40

Operation on three stove basis.
Stove on gas 240 minutes.
Stove on blast 120 minutes.
Blast temperature—1250 deg. F.

9.	Cu. ft. Wind per Ton Iron	105,000	105,000	105,000	105,000	105,000
10.	Heat in 44,000 cu. ft. Blast for 120 min. at 1250 deg. Blast Temp.			110,000,000 Btu.		
11.	Cu. ft. Gas Required Per Min.			6,900 cu. ft. per stove		
12.	Total Heat in Gas			158,000,000 Btu.		
13.	Ratio Heat Input and Output to Heating Surface	1190	1440	1490	1760	1840
14.	Ratio Heat Input and Output to Weight of Brick	86	82	87	86	92
15.	Average Velocity per Second of Gas in Checkers	7.50 ft.	8.10 ft.	7.35 ft.	7.50 ft.	6.85 ft.
16.	Heat Input Rate per sq. ft. Heating Surface per min.	4.92 Btu.	6.03 Btu.	6.20 Btu.	7.37 Btu.	7.65 Btu.
17.	Drop in Temperature of Brick within 1″ of Heating Surface	330 deg.	410 deg.	435 deg.	640 deg.	675 deg.
18.	Ratio Total Heating Surface to cu. ft. Wind per min.	6.40	5.20	5.05	4.25	4.10
19.	Ratio Total Cubic Contents Checkers to cu. ft. Wind per Ton Iron.	0.285	0.292	0.282	0.285	0.266
20.	Ratio Total Cubic Contents Checkers within 1″ Heating Surface to cu. ft. Wind per Ton Iron	0.285	0.238	0.215	0.147	0.138

Operation on Four Stove Basis.

21.	Heat in 44,000 cu. ft. Blast for 60 min. at 1250 deg. F. Blast Temp.			55,000,000 Btu.		
22.	Cu. ft. Gas Required per minute	4600 cu. ft.	4600 cu.ft.	4600 cu. ft.	4600 cu. ft.	4600 cu. ft.
23.	Total Heat in Gas			79,000,000 Btu.		
24.	Ratio Heat Input and Output to Heating Surface	595	720	745	880	920
25.	Ratio Heat Input and Output to Weight of Brickwork	42	41	83.5	43	46
26.	Drop in Temperature within 1″ of Heating Surface	165 deg.	205 deg.	218 deg.	320 deg.	338 deg.
27.	Velocity per sec. of Gas in Checkers	5.8 ft.	6.2 ft.	5.65 ft.	5.8 ft.	5.25 ft.
28.	Heat Input Rate per sq. ft. Heating Surface per minute	3.28 Btu.	4.02 Btu.	4.14 Btu.	4.92 Btu.	5.10 Btu.
29.	Ratio Total Heating Surface to cu. ft. Wind per min.	8.50	6.92	6.70	5.68	5.42
30.	Ratio Total Cub. Contents Checkers to cu. ft. Wind per Ton Iron.	0.381	0.396	0.375	0.381	0.355
31.	Ratio Total Cub. Contents Checkers within 1″ Heating Surface to cu. ft. Wind per Ton Iron	0.381	0.315	0.287	0.196	0.185

The compilation involves an assumption of identical efficiency for all stoves. This cannot be a fact but it involves only the factors under Items Nos. 15 and 27.

Some significant factors are immediately apparent. The cubical contents of the checker brickwork in the second pass is substantially equivalent from a 3½″-square 2″-wall checker to a 6″-square 3″-wall checker. On the other hand, the heating surface suffers a radical and progressive decrease. This results in a lower and lower ratio of heating surface to cubical contents. Were all the cubic contents of brickwork in the stoves of equal utility or efficacy, this would mean that all of the designs would possibly give the same amount of heat, although with a decreasing heat efficiency and increasing use of gas, approximately correspondingly directly and inversely proportional to the ratio of heating surface to cubic contents. This indication is confirmed in Item No. 13, Ratio Heat Input and Output to Heating Surface, and in Item No. 16, Heat Input Rate per sq. ft. Heating Surface per Minute. Here it will be noted that with increasing size of checker opening and increasing size of brick, an increasingly heavier rate of storing and releasing of heat is imposed upon the heating surface. Were the heat transfer from the incandescent brickwork to the relatively cool blast concerned only, the surface will be found quite adequate. But, in the heat transfer from incandescent gases of combustion to brick surfaces continually more nearly approximating the temperature of the gas, experience shows that a heat in put rate of 5.0 Btu per minute per square foot is as high as the rate may be pushed, unless reasonable efficiency is to be adversely affected.

The efficiency of the stoves is also somewhat influenced by the average velocity of gases of combustion in the checkers, Item No. 15. There being in all designs a large number of checkers, one segment of which is near the draft door, then if quite slow velocities are employed there is a distinct tendency of the gases to wander, to much passing down the checkers nearest the draft openings. This tendency is counterbalanced by these same checkers becoming relatively hotter due to the excess incandescent gas passing through, when the cooler checkers will have more nearly taken their proportion. Therefore, within reason, the higher the velocity the more utility will be experienced of all the checker openings and the corresponding brick surface and volume. Also, when there are large checker openings the velocity should not be slow because there does not seem to be enough tumbling of the gases induced to get all molecules of the descending gas stream fully and repeatedly in contact with the brick surface.

Fixing attention on the brickwork weight or volume in the stove, Item No. 14, Ratio Heat Input and Output to Weight of Brick, and Item No. 19, Ratio Total Cubic Content Checkers to Wind per Ton of Iron, signify an equivalent and adequate amount of brickwork to store up the necessary heat to be imparted to the blast. In this connection, however, it is well to bring in the fact that not all of the volume of the brick is equally effective. The following table shows the rate of heat input and output in machine made steam pressed brick:

Brick Exposed to Gas Flame.

	Temperature		
	Face.	1″ From Face.	2″ From Face.
One hour	1850	1250	770
Two hours	2000	1450	1075
Three hours	2000	1600	1250
Four hours	2000	1640	1325

Brick Exposed to Cold Blast.

	Temperature		
	Face.	1″ From Face.	2″ From Face.
Start	2000	1640	1325
One hour	800	1250	1280
Two hours	400	800	900

Several tests along these lines have brought about a tacit basing rate that the effective brickwork in stove checkers is that amount within one inch of the heating surface.

With this base, Item 19—Ratio Total Cubic Contents Checkers to cu. ft. Wind per Ton Iron, shows the rapidly decreasing amount of actually effective brickwork in the checkers with increasing size of checker and increasing thickness of brickwork. Item No. 17 shows the unfortunate result of this fact. 400 deg. is, in an entirely practical way, the limit in drop of temperature of stove brickwork. Any particular margin over this results in inability to carry a straight line heat and entire absence of a heat reserve.

Putting aside further analysis, it is apparent and may be stated that in a hot blast stove, a study of economical use of brick and space inside the shell emphasizes that only the heating surface of the brick and the brick within one inch of heating surface are of any value. This would be reached to the greatest degree by 2″ checkers and 2″ openings. As this is not practical, one can only make the checker walls as thin as is consistent with strength, and the checker opening as small as is consistent with cleanliness of the gases, and accuracy of dimensions obtained in brick manufacture. Apparently, the design shown under 3½″ x 3½″ checkers embodies to the greatest degree all the important advantages and high ratings in heating surface, effective cubic contents of brickwork, low heat transfer rate, and low temperature drop. It has a considerable heat reserve. All requirements for good heat equipment are found in a battery of three stoves. There are no other types of lining adequate in a three stove equipment unless the area of the stove checkers, or its height, be increased by approximately twenty-five per cent.

There are certain serious objections to a battery of but three stoves. Since the checkers must have small openings the gas must be very clean, not to exceed 0.25 grains dust, or the checkers will plug up, the stoves will have to be taken off for cleaning, and there will be recourse to but two stoves, one on blast and one on gas. Unless a forced gas burner is used, insufficient gas can be forced into the stove in the two hour period to carry an adequate blast temperature for the following two-hour period. Unless the brick dimensions are very nearly correct, less than 2 per cent deviation, the checkers may shift and partially close up the checker opening. Repairs that take a stove off blast seriously impair good furnace practice. A 2″ checker brick is more apt to fail, both structurally and from the effect of heat, alkaline salts and dust, than a 2½″ or 3″ brick.

If past experience, which has very satisfactorily proven the practicability of the small checker stove, does not suffice to establish certainty as to soundness of investment in and construction of this type, then the only recourse is to four stoves. An increase in size of checker, thickness of checker brick and consequent increase in diameter and height of stove does not, in any sense, get away from the occasional use of two stoves.

An increase to four stoves is an increase of thirty-three per cent in heat equipment cost, or about three and one-half per cent increase in cost of plant. If this investment is to be made, it should at least be made wisely. A study of the tabulation under four stove equipment heading indicates that any of the designs are quite adequate, all four stoves being in service. However, in view of the apprehension of a stove going out of service if only three were installed, it would be a bit short-sighted to ignore the possibility of having to operate on three stoves. Therefore, one ought to so provide that if operations are reduced to three stoves, then they will suffice to at least carry the usual heat, but now with no reserve capacity to speak of. Referring to the three stove tabulation, it will be seen that either a 4″ or 4½″ checker with a 2½″ brick will accomplish the desired results.

On a single furnace plant, there is no doubt but that the four stove equipment is a better insurance. It is perhaps the last word in insurance but if there does not have to be rigid economy, it is as good a place to carry an excess cost as anywhere in the plant. If there does have to be economy, the 3½" checker three stove is clearly indicated. It has worked out satisfactorily. Of course there also has to be a really effective gas cleaning installation. However, this is true of any size checker up to 6" opening. In conjunction with the choice of three stoves, on the basis of a 3½" checker opening, it is to be kept in mind that such equipment is an excellent base on which to start with the expectation of a two furnace plant. This would have a complement of seven stoves of this type for two furnaces, thereby assuring three stoves per furnace.

The cost of any one of the above types is substantially equal. The shell and stove trimmings are the same, and the number of brick in ring walls, piers, arches and combustion chamber lining are identical. The number of 9" equivalents in the checkers is substantially equivalent, though of course there is more labor in setting 9" x 6" x 2" checker tile than 13½"x6"x3" checker tile, there being so many more of the former.

Not less important than utilizing the volumetric capacity of a given stove shell to the utmost practical advantage is the necessity of correct hot blast stove design and construction. Designs should be chosen which embody every precaution and advantage developed as the result of practical experience in construction, service, operation and repair. The loads and stresses in the brickwork of hot blast stoves are not static loads but by reason of the alternate heating and cooling of a large mass of brickwork, may be termed "live." It is disregard of this fact that has led to not infrequent most expensive failures. The most usual points of failure, refractory quality aside, are springing and collapse of combustion chamber walls, breakdown of tile, secondary and primary arches, and piers in the bottom of the checkers, shifting of checkers, uncompensated expansion of ring walls and checkers, and failure of dome and dome base.

In an operating way, the usual handicaps in effective use of large quantities of gas are fluttering and surging of the gas flame at the burner and in the combustion chamber, ineffective use of full checker area, limited capacity to take gas when the occasion arises, and insufficient draft due to restricted and small chimney valves, draft chambers and stacks.

The quality of refractories used in hot blast stoves is very important, and here too experience is the best guide. Probably the best practice and construction today involves the use of four qualities of firebrick. Experiments are being carried out with new materials, for this particular use, which may mark a distinct advance.

The writer hopes to have pointed out the advisability of adequate investment in good heat equipment, to have analyzed possible types, to have indicated a logical choice of stove equipment, and especially the importance of choosing designs which from the construction standpoint embody features grounded in practical operation, construction and repair developments for the fixing of some of the somewhat intangible requisites for durable and serviceable equipment.

New Blast Furnace at McKeesport

The National Tube Company Rebuild Blast Furnace No. 3 at Their McKeesport Plant from the Ground Up—All the Improvements Have Not as Yet Been Completed.

By DONALD N. WATKINS

ONE of the most important of the recent improvements completed by the National Tube Company at their McKeesport, Pa., plant was the building of a new blast furnace on the site formerly occupied by the old No. 3 furnace. The old furnace was blown out July 1, 1920, and construction work was immediately started on the building of the new furnace. This was completed and put in blast November 15, 1920.

The rebuilding of this furnace was in keeping with the general policy of the Steel Corporation, which is to improve all blast furnaces as the opportunity presents itself.

The history of the original No. 3 blast furnace is very interesting and dates back to the year 1889, when its construction was first started. As will be seen from the following record, it has had a remarkable run:

RECORD

Blown in......................Dec. 4, 1890
Blown out for relining.........April 26, 1894
Blown in......................Sept. 7, 1894
Blown out for reconstruction...Sept. 19, 1900
Ten feet added to its height, relined and changed from a vertical to a skip hoist.
Blown in......................Jan. 26, 1901
Blown out for relining.........June 21, 1904
Blown in......................July 28, 1904
Blown out for reconstruction...Nov. 16, 1907
New shell constructed and relined.
Blown in......................June 14, 1909
Blown out......................July 1, 1920

As will be seen from the above record, the furnace had been in the same jacket for the past 13 years and it was deemed necessary to rebuild the entire furnace and its auxiliary equipment at this time only because it was impossible to secured increased hearth area by relining.

The program of improvements originally included the building of a new stack, down-comers, dust-catcher, and gas-cleaning equipment, along with the reconstruction of the four stoves. Up to the present time the new stack, the down-comers, and the dust-catchers only have been completed.

The old stack was completely demolished and a new one erected from the foundation up. The new furnace has a height of 90 feet, hearth and bosh diameters of 18 feet and 22 feet respectively, and has an 80-degree, 32-minute bosh angle. The shell is of unusually heavy construction, being made up entirely of 1-inch plates except the bottom ring, which is 1¼ inches thick.

The hearth jacket is of water cooled cast iron construction, 6 inches thick with 1¼-inch tuyere pipe cast in. The new lining involves a total of 484,000 bricks, and gives a furnace capacity of 24,000 cubic feet. The stock lined protection consists of 7 courses of steel cast wearing plates 3 inches thick, 33 to the course imbedded in the brick. The large bell is 13 feet in diameter. The McKee revolving stock distributor is electrically driven and controlled.

Harbison-Walker bottom blocks, 18x12x8 inches are used. All refractories used in the lining of the furnace were furnished by the Harbison-Walker Company.

Several interesting features stand out most prominently in the construction of this stack. To begin with, it is a hand filled furnace, that is it is hand filled in the stock house; has a McKee distributor which helps to preserve the furnace lining and increases the production; and the stack is built, as stated above, along unusually heavy lines.

There are four explosion stacks equipped with safety explosion valves. The four down-comer branches leave the explosion stacks at about 31 feet above the top of the furnace and connect in pairs to form two down-comers. All pipes are lined with 4½-inch fire brick.

The dust catcher is built of ½-inch steel plate and lined with 4½-inch fire brick. It is also equipped with an explosion valve at the top. The dust catcher is 22 feet outside diameter and 25 feet high. The two down-comers enter at the side and the gas leaves the dust-catcher at the top.

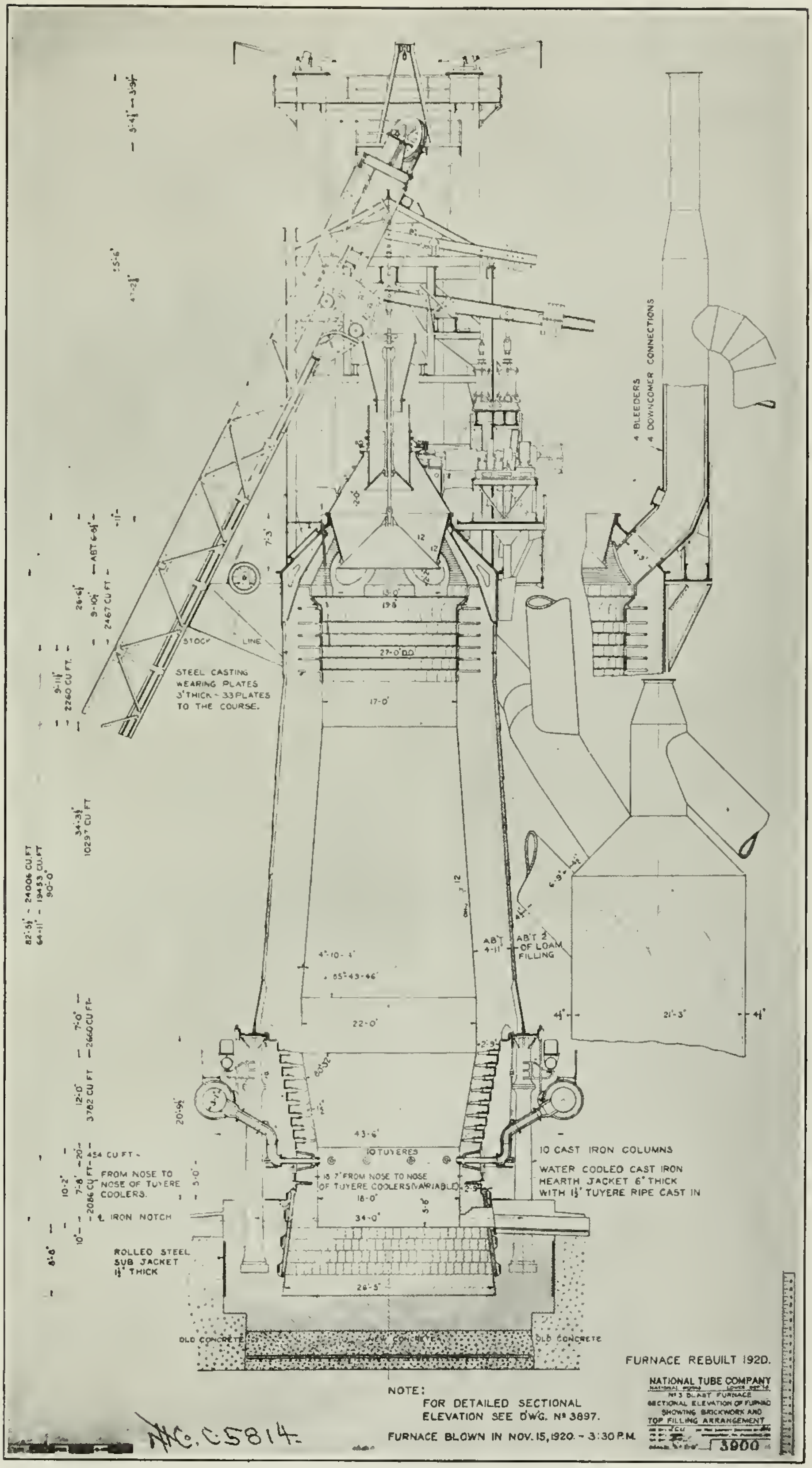

4 BLEEDERS
4 DOWNCOMER CONNECTIONS
STOCK LINE
STEEL CASTING WEARING PLATES 3" THICK - 33 PLATES TO THE COURSE.
27-0 OD
17-0
19-6
ABT 4-11
ABT 2' OF LOAM FILLING
4'-10-4
65°-43-46
22-0
21'-3"
43-6
10 TUYERES
FROM NOSE TO NOSE OF TUYERE COOLERS.
IRON NOTCH
ROLLED STEEL SUB JACKET 1¼" THICK
18-0
34-0
26-5
OLD CONCRETE
NEW CONCRETE
10 CAST IRON COLUMNS
WATER COOLED CAST IRON HEARTH JACKET 6" THICK WITH 1¼" TUYERE RIPE CAST IN
FURNACE REBUILT 1920.
NATIONAL TUBE COMPANY
Nº 3 BLAST FURNACE
SECTIONAL ELEVATION OF FURNACE SHOWING BRICKWORK AND TOP FILLING ARRANGEMENT
3900
NOTE: FOR DETAILED SECTIONAL ELEVATION SEE DWG. Nº 3897.
FURNACE BLOWN IN NOV. 15, 1920. - 3:30 P.M.
NC. C5814.

Fig. 1—Section through the new stack.

There are four stoves used in connection with the furnace. Three of these, which are of the side combustion, two-pass Cowper type, and were originally constructed in 1889, are to be rebuilt in the immediate future. The fourth stove, which is of M. and C. three-pass design, was built at a later date. The real capacity of the new stack has not as yet been tested due to the fact that the old stoves have not sufficient heating surface to test the new furnace.

The building of the furnace was directly under the supervision of the Engineering Department located at the National Works. Mr. A. L. Hoerr is the chief engineer of this plant. In the designing of the new stack the Engineering Department was ably assisted by ideas and suggestions advanced by the operating officials of the blast furnace department, of which department Mr. M. R. Stevenson is the superintendent.

Hammer-Welded Steel Pipe

Hammer-Forging Can Be Adapted to the Manufacture of Pipe from 24 to 96 Inches in Diameter—The Process, the Materials Used, Characteristics of the Pipe and Its Testing Briefly Described.

THE Process of making lap-weld pipe by hammer-welding is relatively new as compared with the butt-weld and lap-weld processes and the sizes made by hammer-welding are, relatively, much larger in diameter.

The pipe is made by bending a steel plate into tubular form with edges overlapping and then welding the overlapped edges after they have been heated, by hammer-forging them on an anvil block supported on a horn inside the pipe.

The process of hammer-welding is particularly well adapted to the manufacture of pipe in sizes from about 24 to 96 inches. Due to the simplicity of manufacture—in that rivets, projecting ribs, and other objectionable features are eliminated — hammer-weld pipe has a relatively high efficiency.

The strength and ductility of the material, the sound and smooth-welded seam, the simple and efficient types of joints that can be used, and other advantages make hammer-weld pipe desirable for almost any purpose requiring large diameter pipe.

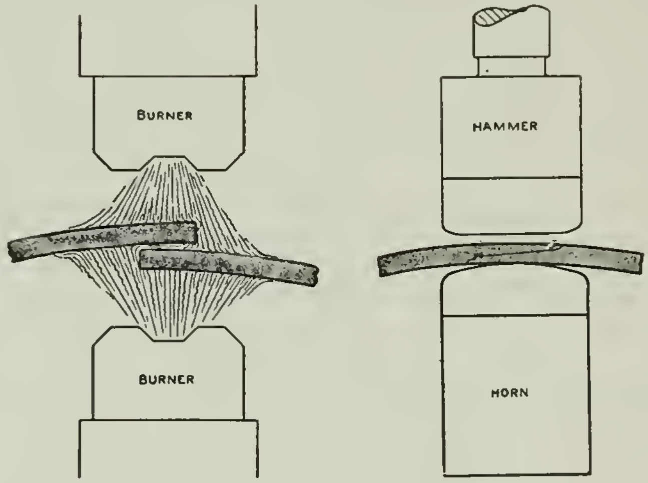


Diagram illustrating principle of hammer-welding. The left-hand drawing shows water gas burners heating the overlapped edges of the tube, inside and outside. Note the flame is directed on all surfaces of the portion to be welded, thus insuring uniform temperature. After heating, the hammer, shown in the drawing at the right, forges the overlapped edges into a strong weld on the anvil block which is supported by a long beam or horn.

Manufacture and Materials.

The plates used in the manufacture of this pipe by the National Tube Company are made in accordance with A. S. T. M. Specification A-78-21T and are of open hearth steel of a grade to give the best results in welding and other manipulations in manufacture. The plates may either be bent cold, or heated and bent, depending upon their thickness.

The tubular, or cylindrical form is obtained by bending the plate on long horizontal rolls, in much the same manner as plates are bent for boiler shells and tank construction. However, they are bent completely around until the edges overlap to the required extent and the proper diameter of the pipe is obtained. In certain sizes, two or more plates may be used with similar overlapped edges. Sufficient lap is allowed to make sure that the force of the welding hammer will be most effective in wedging the edges together.

The rough tube thus obtained is taken to the welding machine where a short section of the overlapped edges is heated to a welding temperature by water gas burners, placed opposite—inside and outside the pipe. After reaching the proper temperature, the heated portion of the seam is hammer-forged on an anvil supported by a long counterbalanced beam, after which the contiguous portion is heated and welded. The welding machinery is developed to a point which allows the operator to direct every blow with the accuracy of the skilled smith with his sledge. The power hammer can be operated at a high rate of speed and can be regulated to hit with the varying degrees of force necessary to make a strong weld.

After being welded, the pipe is placed in an annealing furnace and heated to a temperature to remove strains and refine the grain. It is then subjected to another operation on horizontal rolls to round up the pipe, straighten it, and remove such scale as may have formed during manufacture.

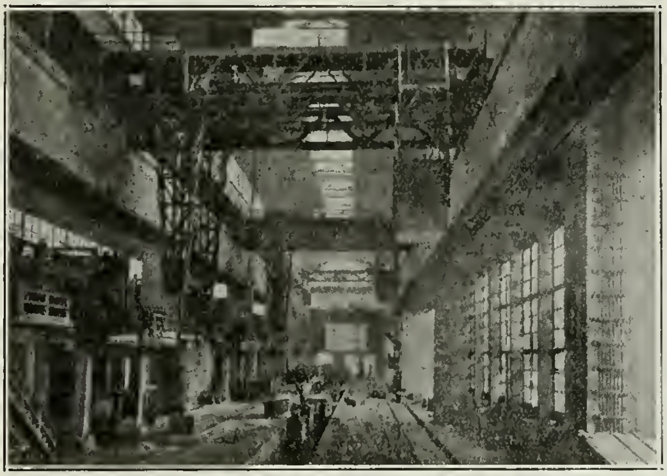
When the pipe has been welded, annealed and straightened, it is given a premilinary inspection. The ends are then trimmed to any desired angle or length.

Each length of pipe is subjected to an internal hydrostatic pressure test. The pressure varies from 150 to 2,000 pounds per square inch, according to the size and wall-thickness of the pipe and the service for which it is intended.

After the hydrostatic pressure test, the pipe is given a thorough inspection as to surface, finish and dimensions and a protective coating is applied if required by the customer. The pipe is then stenciled with the name of the manufacturer and the pressure applied in testing, after which it is ready for stock or shipment.

Abstract of Bulletin No. 13, entitled, "Hammer-Welded Steel Pipe," published and copyrighted, 1921, by the National Tube Company, Pittsburgh.

Steel Works Department



Recent Developments in Open Hearth Furnaces
By HENRY WILLIAM SELDON

Progress of Electric Steel Furnace
By EDWARD T. MOORE

Manufacture of Commercially Pure Iron
By D. M. STRICKLAND

The Acid Electric Steel Process
By R. J. WEITLANER

Open Hearth Furnace Makes a Record

Graphical Treatment of Stack Gas Analysis and of Fuel Gas Analysis
By W. TRINKS

Recent Developments in Open Hearth Furnaces

Open Hearths Were Standardized Along Modern Lines During the Past Year—Open Hearth Hourly Tonnage Increased 115 Per Cent During Year.

By HENRY WILLIAM SELDON, B.S., Met. Eng.*

FOR many years open hearth furnace construction followed the same general plans and each furnace performance was judged by the records of the past. Starting with the war time conditions there arose a demand for increased tonnages per unit. The scarcity and high price of coal, oil, gas, etc., caused a demand for better fuel economy.

Fathered by these conditions it is not surprising that we have had new as well as old ideas tried out. Under the conditions existing in many plants heretofore the suggestion or development of new or so-called radical ideas was not encouraged, with the result that we made but little advancement in open hearth practice.

In order to convert an inefficient open hearth into a thoroughly modern one the following items should be carefully considered:

1. Hourly tonnage
2. Fuel economy
3. Valves
4. Sewers
5. Checkers
6. Ports
7. Roof
8. Burners
9. Uptakes
10. Slag pockets
11. Charging machines
12. Doors, frames, etc.
13. Gas producers
14. Bottom making

1. Hourly Tonnage.

The hourly tonnage or tons/hour output of an open hearth furnace has been increased as much as 115 per cent.

2. Fuel Economy.

The fuel economy has been surprising and as an example we give the following from producer gas results. For a long time 550 pounds of coal per ton of steel was considered good practice. With the latest practice this figure has been reduced to 350 pounds/ton.

3. Valves.

Valve builders and designers have been striving to attain a product which would be simple to operate, thoroughly reliable and could be easily and quickly repaired.

The designs most favored at present are water sealed, instantaneous mechanical reversing, fuel saving, having ample port areas, offering minimum resistance to flow of gases and occupying minimum floor space.

4. Sewers.

The trend in sewer design has been toward increased size and straight lines with the elimination of sharp angles and obstructions. Considerable change has taken place in producer gas main design. The value of oversize mains, easy curves, ample soot catchers and suitable burning out facilities is being recognized. Overhead mains and interchangeable producers are advocated.

5. Checkers.

The checker problem is an individual one for each plant to solve by experience.

The tendency is towards the use of thinner brick with an increase in the vertical dimensions of settings.

The use of checker brick having a higher refractoriness than fire clay is advocated with the idea of imparting a higher preheat to the incoming gases.

Oversize checker chambers are being used to advantage. During the early run of a furnace the excess number of checker flues are covered with tile. As the furnace ages and the draft becomes impaired these tile are removed. Numerous schemes are in use for cleaning the checkers without taking the furnace off.

The effect of checker resistance to the gases passing through is more generally understood and influences the type of setting.

6. Ports.

The ports on a producer gas furnace have ever been the cause of much trouble and loss and it has not been long since the life of the port governed the life of the roof and in cases the life of the furnace. With the present ports this is not the case and the ports outlive several rebuildings.

The original brick gas port has been gradually reinforced by water cooling until the bricks become the minority. Many plants still prefer to do their own water cooling with curved pipe at the nose, but the commercial water cooled ports are gradually winning out.

The latest ports are designed with the idea of securing quicker and more perfect fuel burning and of the numerous types being developed much has already been accomplished. The heat time as well as the amount of fuel per ton has been materially reduced.

7. Roof.

The ribbed roof is now firmly established in open hearth practice and the debated points are mainly as to the length of brick.

Researches are being made to find a brick which will possess all the good qualities of a silica brick and in addition have a fusion point considerably higher. This search is not being confined to the so-called cheaper materials alone, but to the high priced refractories which have previously only been used for special work.

In a few shops the bonded roof has been adopted with excellent results.

Experimenting is also being done to determine the most efficient height to build the roof to secure better fuel burning.

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*Mr. Seldon is a member of the firm of See-Seldon and Associates, Engineers, Oliver Building, Pittsburgh, Pa.

8. Burners.

Burner design has received special attention and has resulted in a big saving of fuel. The heat times have been reduced and the utilization of fuels and combinations of fuels has been made possible which had previously been impossible.

9. Uptakes.

The uptakes of the present day open hearth are being made the objects of much changing. The general trend is toward increased area.

In several of the newer types of furnace the air uptake area is controlled by the installation of either slide or mushroom dampers which cannot be connected with the reversing mechanism.

The air uptake designs vary from a single uptake which extends across the entire end of the furnace in one case to another in which a portion of the air for combustion is by-passed and introduced into the gas port at an angle a short distance behind the nose.

The aim of each design is to obtain "blow pipe action," thereby securing quicker combustion and intense sectional heating which results in faster melting and, with the proper regulation better fuel economy.

It has been demonstrated that it is possible to obtain this desired action by the proper port design.

The use of a fan for introducing the necessary air for combustion under pressure is the plan adopted in several designs, but this method is still detrimental to furnace life.

10. Slag Pockets.

Slag pocket design has been advancing along the lines of increased size and speed of cleaning.

Modern practice demands the frequent removal of the slag without taking the furnace off for minor repairs.

There are numerous methods of water cooling in the slag pockets for accomplishing this purpose. Interchangeable buggies are also used for this purpose.

11. Charging Machines.

Mechanical charging machines have practically eliminated the old hand charging process. The machine most preferred at present is the low type and one in which the operator and control is separated from the peel. The demand is for faster machines and stronger motors.

12. Doors, Frames, Etc.

The change in this equipment has been to water cooling and larger sizes. Some progress has been made in making the frames in more than one piece. Cast and welded steel are used in excess with many buckstays still made from slabs and structural shapes.

Water cooling equipment is being used for bulkheads, slag lines, back walls and chills in addition to those mentioned.

13. Gas Producers.

Mechanical gas producers have practically eliminated the old hand operated machines in all of the larger plants.

This has been caused by the desire to produce more and better gas from a given unit and the difficulty of securing competent and reliable operators.

There are a number of makes of full and semi-mechanical producers on the market in which the gas making operations are done mechanically.

All the latest types are water sealed and use a mixture of steam and air. In addition to a steam jet blower a turbo blower is supplied with facilities for admitting live steam to the blast.

Any producer requires experienced and careful operation and the quality of the coal used is also important.

14. Bottom Making.

Considerable experimenting has been done to develop a satisfactory mechanical means for making bottom. Several devices are available for patching the back wall slag line.

The inability to secure Austrian magnesite for bottom making resulted in the development of our American magnesite deposits. Numerous substitute materials were put on the market for this purpose with varying degrees of success. This condition had the effect of forcibly demonstrating to open hearth men the value of good dolomite and the proper care of the bottom.

Progress of Electric Steel Furnace

Although Progress in Electric Steel Furnace Development Has Been Slow During Past Year, Writer Looks for Greatest Developments to Take Place as Business Situation Improves.

By EDWARD T. MOORE*

SINCE its inception about 40 years ago, the progress of development of the electric steel furnace has been one of unusual activity, especially the decade 1909 to 1919.

The year 1920, and more especially the year 1921, will no doubt go down in history as the low-water mark in the growth of electric furnaces since the beginning of its phenomenal advancement over 10 years ago.

The beginning of this rapid growth dates back to the first commercial electric furnace in the United States for melting and refining steel at the works of the Halcomb Steel Company, Syracuse, N. Y., from which the first heat was tapped on April 5, 1906. Since this time there has been a rapid development in technical and operating details, resulting in furnaces of greater capacity being constructed, as the following table will indicate:

Location	*Capacity Tons*	*Date when first heat was tapped*
Halcomb Steel Company..	4	April 5, 1906
Illinois Steel Company....	15	May 10, 1909

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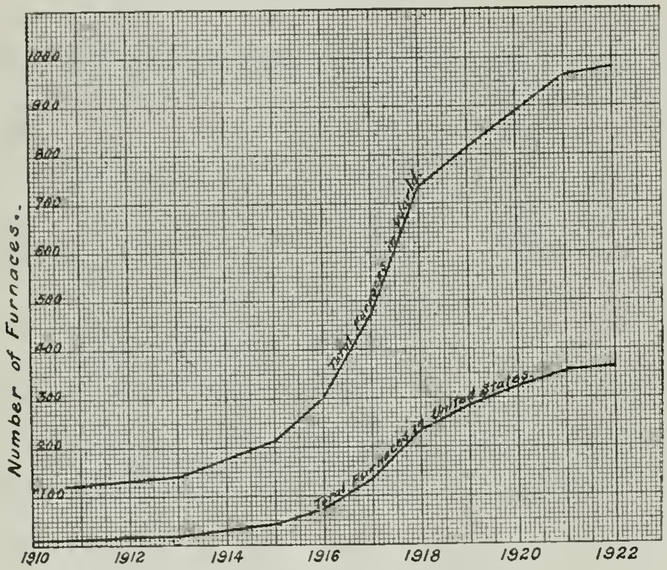
*Mr. Moore is consulting electrical engineer with the Halcomb Steel Company, Syracuse, N. Y. He is also chairman of the Electric Furnace Committee, Association of Iron and Steel Engineers. Also a Fellow and chairman, Syracuse Section, American Institute of Electrical Engineers.

Carnegie Steel Company...	25	Nov. 17, 1916
U.S. Naval Ordnance Plant	40	Feb. 2, 1921

A further indication of the progress of the electric furnace can be gained from Figs. 1 and 2. In 1911 there were only 10 electric steel furnaces in operation in the United States, and the steel produced in them amounted to 29,105 tons. By 1915 the number of furnaces had increased to 41, and the production to 69,412 tons. In 1917 there were in operation 136 furnaces producing 304,543 tons. By 1919 the furnaces numbered 287 and the output was 566,084 tons. On January 1, 1921, 356 furnaces were installed or contracted for in the United States.

In the early days of the electric furnace, a number of single phase units of comparatively small capacity were put into use and are still in service. To date there are approximately 37 single phase furnaces installed as against 319 polyphase units. Since January 1, 1918, so far as can be learned, only five single phase steel furnaces have been installed in this country. It is interesting to note also that of the 356 furnaces now installed, 151 are in plants having two or more furnaces each, the number of such plants totaling 55.



Electric Steel Furnace Development.
Figure 1.

As has been noted in the table above, the tapping of the first heats from two 40-ton Heroult steel furnaces at the U. S. Naval Ordnance plant, South Charleston, W. Va., on February 2, 1921, marked a considerable step forward in electric furnace construction and in the electrometallurgy of steel and iron. This is probably the greatest development during the year just passed and consequently is of great interest and value, not only to the electrical engineer, chemist, and metallurgist, but, in this specific case, to those concerned in the manufacture and application of ordnance and armor.

These 40-ton electric furnaces are operated in conjunction with two 75-ton basic open hearth furnaces using natural gas of 950 to 1000 Btu., and after dephosphorizing, the molten steel is transferred to the electric to be desulphurized, deoxidized, and brought to the final temperature preparatory to teeming and casting.

Each electric furnace is basic lined and has a transformer capacity of 3300 kva. The transformers, built by the General Electric Company, are water-cooled 3 phase units with a primary for 6600 volts operation and taps arranged so that full input can be obtained at 100 or 90 volts as desired in the furnace, the last connection giving 21,200 amperes per phase.

All the electrical equipment used with these furnaces is practically standard, including the regulators, switchboard and meters.

One of the furnaces is equipped with 24-in. diameter amorphous carbon electrodes and the other one with 14-in. diameter graphite electrodes, thus giving current densities of 46.8 and 137.5 amperes per square inch respectively with the transformer at its maximum output of 21,000 amperes per phase. Some very excellent data has no doubt been secured on the relative electrode consumptions, breakage, and other troubles causing delays.

While these furnaces are of the largest capacity yet installed, negotiations are under way, it is understood, to install 60-ton electrics in Henry Ford's plant at River Rouge, so that the year 1921 will be notable principally for the development of larger capacities.

Reactance.

Considerable study has been made of the reactance of furnace circuits and much improvement secured by properly installing this feature. The reactance must be depended upon to limit the value of the current surges that may occur during the melting down portion of the operating cycle. These surges may be due to pieces of metal falling against the electrodes and causing momentary short circuits, or to establishing the arc, after it has been broken by the rapid melting away of the metal. The frequency and duration of these surges depend largely on the care used by the operator in charging the furnace. During the refining period, surges are of much smaller magnitude and very much less frequent, so that the value of reactance used, while usually the same, should preferably be reduced, with much improvement to power factor.

Power factor and reactance are intimately connected, and considerable harm has been done by advocating too high a power factor. Public reference was recently made to the unsatisfactory operating characteristics of a 3 ton, 3 phase, 100 kva. furnace taking power from a 11,000 volt, 25 cycle circuit. On account of the low reactance of this equipment, it is common occurrence for the oil breaker to open several times during a heat, and as this breaker is set at six times normal current a reactance of approximately 16 per cent is indicated, which should give a power factor of over 98 per cent—a figure unnecessarily high.

If the reactance was doubled, the power factor would be still approximately 95 per cent, while the short circuit current would be decreased from 600 per cent to 320 per cent. If the reactance was still further increased to 43.6 per cent the power factor would still have the excellent value of 90 per cent and the short circuit current would be 229 per cent. This seems to be a desirable value although if still better protection is desired, such as on a small capacity privately owned plant, a reactance value of 53 per cent would give a power factor of 85 per cent and a short circuit current of 190 per cent. These figures are based on values that would be obtained with a reactance having the characteristic of the air core type, which is generally used in furnace installations, and would necessarily be altered for iron core reactors and reactors of the compounding type, such as saturated reactors.

A 6 ton, 3 phase furnace having transformer capacity of 1500 kva. on a 60 cycle circuit will have approximately 90 per cent power factor, indicating a reactance of 43.6 per cent, of which about 6 per cent will be in the transformers. The remaining 37.6 per cent reactance, which is principally in the secondary leads, would be reduced to 15.7 per cent on a 25 cycle circuit. The 25 cycle transformer would have a reactance of about 7 per cent, which, added to the 15.7 per cent, would give a total of 2.7 per cent, indicating a power factor of 97.4 per cent with a corresponding short circuit current of 440 per cent. This indicates that to give the smooth operation of a 90 per cent power factor furnace, a 20 per cent reactance should be added to a furnace that normally required no exterior reactance on a 60 cycle circuit. Considerable thought has been given by the writer to a type of reactor having a normal reactance value at rated capacity, but a much higher reactance at overloads and also a reduced reactance at reduced load. The graph (Fig. 3) illustrates the relation between reactance and power factor in a circuit. As abscissae are plotted reactance voltages in percentage of the supply voltage, while the ordinates represent the power factor of the circuit in per cent. Incidentally, the ordinates of this curve also indicate the voltage drop due to resistance in the circuit, or, neglecting the resistance in the transformer and furnace leads, the actual voltage which is obtained across the furnace electrodes in per cent of the supply voltage.

Electrodes.

One of the largest cost items in the manufacture of steel by the electric furnace comes from electrodes, and users of this material have not been careful enough in the past in regard to the handling and proper use of them. In spite of every precaution taken by the manufacturer, careless storage or handling of electrodes by the user will cause trouble. The desirable characteristics of an electrode are:

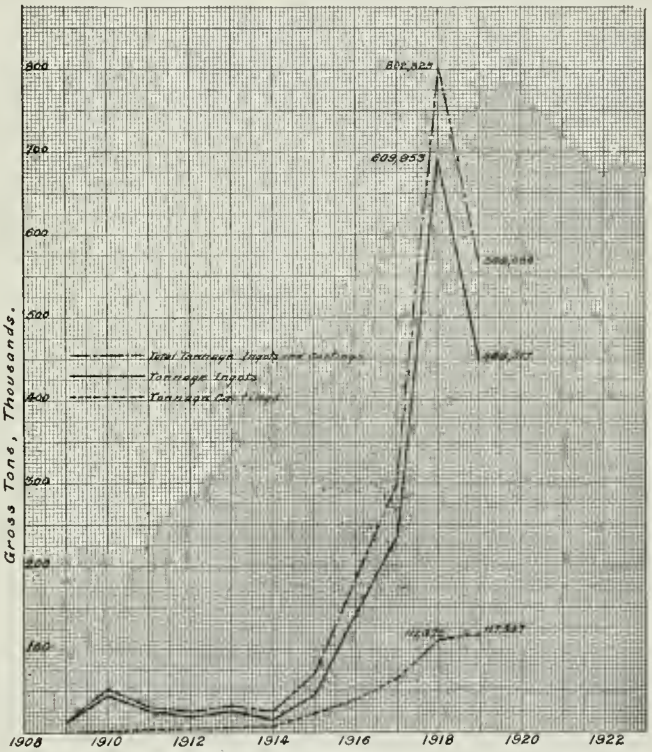
1. Low electrical resistance.
2. Slow rate of oxidation.
3. Strength to withstand the handling received during transportation, installation, and operation.
4. Low heat conductivity.

The prevention of abrasions on the outside surface of electrodes should be particularly guarded against as serious local heating results and hence increased oxidation with attendant excessive electrode waste. The electrode manufacturers have done considerable work toward improving the quality of their product and by increasing the density, much better results have been secured. A specification on furnace electrodes made up by the Electric Furnace Committee of the Association of Iron and Steel Electric Engineers, while an initial effort, will serve as a valuable guide in checking and inspecting electrodes. This specification also outlines a method of determining electrode resistance and specifies that amorphous carbon electrodes should have an average specific resistance of not more than .002 ohm per inch cube at 20 deg. C., with no single electrode above .0025 ohm. With graphite electrodes the average specific resistance should be .00036 ohm per inch cube.

A new development within the past several years which has met with success in the ferro-alloy industry and which has possibilities of being extended to the electric steel furnace is the Söderberg self-baking continuous electrode. This electrode consists of a steel tube filled with prepared carbonaceous material which bakes itself in the furnace in which it is used. Extensions are made to the tube by welding in place and without interfering with the operation, and the tube then filled. As the bottom portion within the furnace burns away the new portion eventually reaches a point within the furnace where baking results, after which it reaches the zone of use. A great economy in electrode cost has been obtained with this type in ferro-silicon furnaces in Norway, and it has been demonstrated in this country at Anniston, Ala., with very favorable results, we understand. On account of the present necessity of using a metal tube or jacket, it is questionable if it could be used successfully in steel furnaces. With some modifications, however, it no doubt can be adapted for the steel furnace and should eliminate the present costly delays due to electrode handling and breakage.

Regulators.

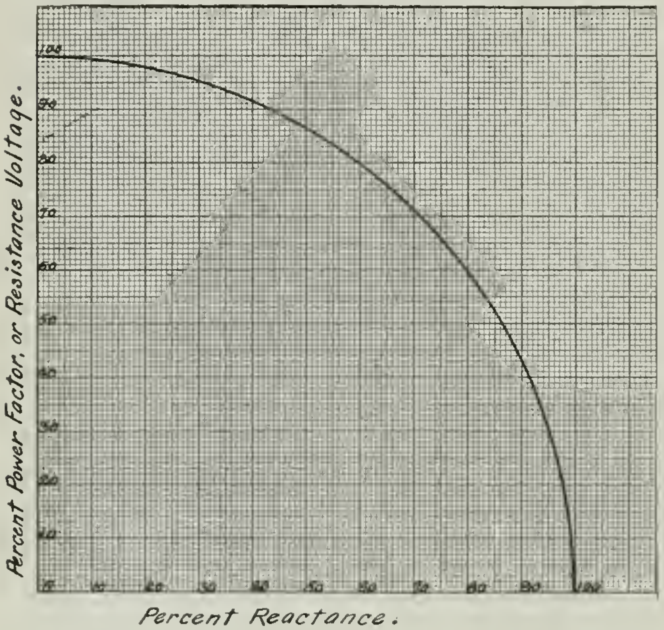
It is the duty of the regluator to so control the position of the electrodes automatically with respect to the furnace charge that one component of the power input will remain substantially constant, regardless of other conditions within the furnace. On account of the mechanical and electrical inertia of the system, a time lag exists between the change of the regulated quantity and its effect on the position of the electrodes, and in attempting to obtain high speed and precision, a condition known as "hunting" is invariably encountered. When an elementary control is employed to maintain an unstable quantity constant, it is necessary to either operate at low speeds, or to be satisfied with reduced accuracy, or to strike a compromise on both. Owing to the inertia of the moving parts, however, the electrode motor will drift somewhat, and if a fairly high electrode speed is used, the electrode will over-travel a sufficient amount to change the regulated quantity to the opposite side of its normal value.



Electic Steel Production.
Figure 2.

In order to combine the advantage of high speed and at the same time eliminate over-travel of the electrode, the Westinghouse Electric & Manufacturing Company has developed a new regulator which allows the electrode motor to operate continuously, and the electrodes at high speed, until the current reaches to within approximately 15 per cent of its normal value. Between this 15 per cent point and the normal value of the current the regulator assumes a vibrating condition, and the electrode motors are subjected to a series of impulses, the average time the motor is connected to the circuit being a function of the amount the furnace current deviates at any particular instant from its normal value. There are two distinct stages, therefore, in the operation of the regulator, one being the continuously running stage and the other the vibrating stage. The vibrating feature permits the motors to operate at a high speed until the current in the electrode has been brought back to within approximately 15 per cent of normal, when the speed is gradually reduced to zero. High speed and freedom from over shooting are thus obtained.

Action is secured by current and voltage coils, the current coil being connected as usual and the voltage coil connected between the electrode and furnace shell. On account of the voltage element, it is impossible for the electrode to dip into the bath and is an advantage, particularly when producing low carbon steel. This voltage element in the control of each electrode makes each unit independent of the others, and in addition serves as a no-voltage release.



Relation between Reactance and Power Factor of a Circuit at Normal Kva Load.

Fig. 3.

It is said that the new features of this regulator permit the furnace to be placed on automatic regulation on a cold charge immediately, and in cases where the electrode bores into the charge, which later falls in around it and causes the breaker to trip out, that the regulator will act to extricate the electrode in a large majority of cases before the breaker is tripped.

Electrodynamic Forces.

In a paper presented before the American Electrochemical Society, Dr. Hering discusses a number of quite recently discovered mechanical forces in electric furnaces which are of electric origin. These forces may be made use of, or may be detrimental, in some types of electric furnaces, chiefly those in which the heat-developing resistor is a liquid, which responds to these forces more readily than a solid. Such forces may be usefully applied to cause the liquid metal to flow rapidly through the heat-developing resistor, thereby enabling the furnace to be forced, and to cause a strong upward circulation in an adjoining bath, by which the metal is refined of suspended impurities and made homogeneous. Reference is made to the well known "pinch effect" as well as the newer "corner effect" and "stretch effect." Much opportunity remains in this field of high current density to study the existent mechanical forces, but great perseverance is necessary on the part of the investigator as direct experiments are tedious and difficult, as so many foreign factors are likely to enter to mask the results. The majority of these forces probably increase with the square of the current, and may therefore not be very evident until the currents become very large.

Induction Steel Furnace.

The first ones to recognize the possibility of heating by induction currents were deFerranti and Colby, and it is generally conceded that the basic use of the transformer principle to electric furnaces was independently applied by both of these inventors in 1887, the dates of their patent applications being but a few months apart. Their design, however, was never put to practical use although some of the early principles adopted by Colby closely resemble present day apparatus and probably because of the more practical nature of his developments was awarded the Franklin Institute Medal for his induction furnace.

After the first early developments of the induction furnace it seemed to be overshadowed by the success of the arc furnace, as prior to 1914 the largest unit of the induction type in the United States had a capacity of only two tons. The inherent low power factor of the furnace and the difficulty of maintaining a satisfactory refractory lining were greatly responsible for this lack of development.

In 1914 two induction furnaces of 20 tons capacity were installed and at that time were the largest of any type in the United States. This supremacy continued until the installation of a 25-ton Heroult furnace in 1916. These 20-ton induction furnaces were of the two-ring type and in operation utilized single phase current of five-cycle frequency at 5000 volts with a special motor-generator set having an output of 4000 kva. at 5000 volts, 5 cycles and driven by a three phase, 25 cycle, 2300 volt synchronous motor. In operation the furnace rings are charged with molten metal, every part of which is thereby subjected to intense, uniform and positively controlled heat, and is then poured off after a treatment lasting from 60 to 90 minutes.

These large size induction furnaces have not been entirely successful and, it is understood, have been out of service for some time. The refractory expense in these large furnaces is very high and for general work the arc furnace has been found quite superior. This relationship may be changed in the future for special applications as a two ton induction furnace developed by the General Electric Company has recently completed a run of 555 heats on one lining. This is exceptional performance, especially when we consider that each heat consisted in melting high silicon steel scrap on a magnesite lining; but as the desired results could not be obtained readily in any other way it was necessary to follow this apparently incongruous practice. Assuming the same results could be obtained with the arc furnace, the lining cost of induction furnace is considerably below the single item of electrode cost in the arc furnace, while the figures for power consumption are comparable. The development of a new furnace lining called "furnite" has done much to render this furnace successful, and unquestionably larger units of this particular type will be forthcoming.

Conclusion.

Of necessity this review must be incomplete as many developments are not learned till long after their inception and usually a considerable time elapses between the inception and application to actual practice. Those desiring to pursue this subject further may do so by referring to the articles in the bibliography following, to the authors of which we are indebted for much of our information.

It would be a great mistake to surmise that the rather retarded progress during the past year foretells any slowing down of progress in electric steel furnace development. Indeed, it rather lays emphasis on how far and how fast the art has advanced. During periods of relative inaction, such as the past year, a great deal of thought and conception is taking place and when finances are such that these theories may be tried out in practice, we are bound to reap in the harvest, not far distant, the results of our work at this time.

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Manufacture of Commercially Pure Iron

Departures from the Usual Manufacturing Procedures in Making Pure Iron—Analyses Show Difference Between Common Steel Slags and Commercial Pure Iron Slags.

By D. M. STRICKLAND*

DURING the mythical days, so vividly described in "The Arabian Nights," it would have only been necessary in order to obtain commercially pure iron that Aladdin rub his old lamp and request the appearing genii to respond with a delivery. However, this was a long, long time ago. The gnomes and fairies no longer respond to the demands of mortals, so mankind, denied the privilege of simply asking for its requirements, has been forced to develop and produce life's comforts and necessities wholly unaided by supernatural powers.

In fact, hundreds of years have passed since the famous old lamp ceased to function. Consequently, the abilities of men have been steadily increasing until today the products of their achievements far surpass the most fantastical or imaginative myth ever dreamed by a Persian nobleman. It has remained for the scientists of the twentieth century to perfect the methods of ore reduction and purification to the high degree where it is possible to produce commercially pure iron economically and in quantities sufficient to successfully bring this product to the attention of present day users.

Needless to say, the development of commercially pure iron has not been the result of a series of fortunate accidents, but, on the other hand, has only been accomplished after careful thought, repeated experiments, and adaptation of existing manufacturing methods to meet the requirements necessitated for the production of the metal desired. Commercially pure iron manufacture does not commence with the open hearth process. Neither is the blast furnace the starting point. It is necessary to go to the source of all ferrous metal production, namely, iron ore.

Since the development of commercially pure iron is a purification process, the choice of the ore is of vital importance. Obviously, the purer the ore, the fewer initial impurities require elimination. It is for this reason that the ore is selected with exacting care and only that of the highest quality is used for the subsequent reduction. When the ore is obtained, the process of commercially pure iron production becomes two-fold; first,

Fig. 1.

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*The author of this paper is the chemist of the American Rolling Mill Company at Middletown, Ohio.

the efforts necessarily expended in reducing the ore itself; and, second, continuous fighting to keep the product free from contamination due to impurities existing in such raw materials as are required in the purification process.

Using the purest limestones and cokes obtainable, the high grade ore is reduced in the blast furnace with a result that the contaminating impurities in the pig iron are reduced to a minimum. It is self-evident that the pig iron, scrap, and other raw supplies used when charging the open hearth furnace are not dumped in haphazardly, but are selected only after repeated analytical examinations, comparison of values and elimination of poor quality materials. Even the fuel is analyzed, and, when producer gas is used, each car of coal chosen for gas making purposes must conform to very rigid low sulphur and other quality specifications.

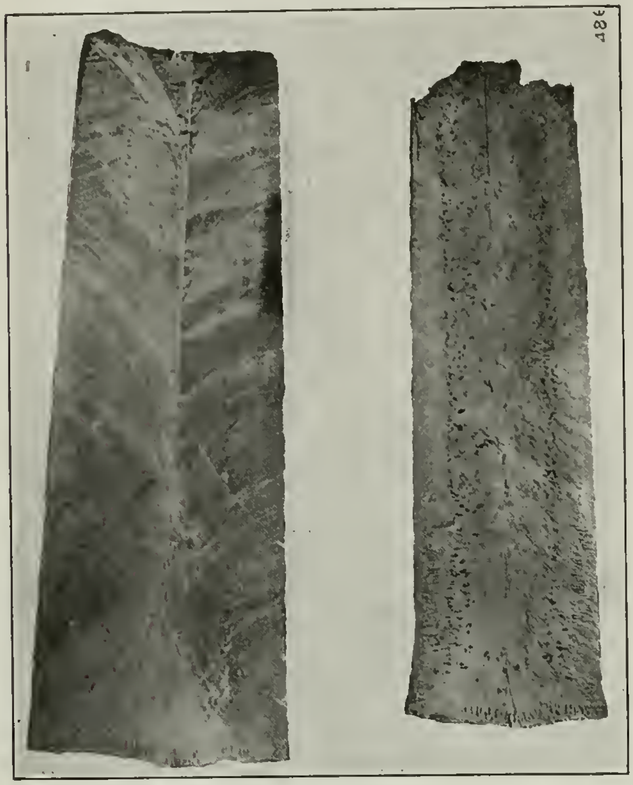


Fig. 2.

Following the usual basic open hearth process, the charge of selected materials is melted down until the heat is in the usual condition for tapping. At this point, however, there is a radical change from the practice as followed for the production of ordinary irons or steels.. Although the molten metal is in condition to tap for the manufacture of these last named metals, yet, commercially pure iron requires additional purification.

The charged limestone having already reduced the sulphur and phosphorus contents to a minimum, pure hematite ore is now added for the purpose of reducing the silicon, carbon, and manganese impurities to such low amounts that the resulting product will contain traces of silicon, sulphur, phosphorus, carbon and manganese in summation of less than two-tenths of one per cent.

Metal tests are taken from the furnace about every 30 minutes during this final additional purification. Ore is added after each test is taken and this procedure is followed until an analysis of the preliminary sample shows that the above mentioned impurities are reduced to such low amounts that the metal conforms to commercially pure iron specifications, the manganese and carbon contents both being below .02 per cent.

The direct and indirect results attending this purification process are many and of decided importance to the commercially pure iron producer. The fact that the heat remains in the furnace from one to four hours longer than when other products are manufactured not only decreases the tonnage output of the furnace, but also requires that the refractory furnace linings be of such high efficiency that they will withstand the continued action of the molten metal. Before a commercially pure iron heat is charged, the bottom and banks of the furnace must be carefully prepared, using the best refractories money can buy.

It is easy to see, since each heat lies in the furnace a few extra hours, that the fuel costs are greatly increased. Also, the molten iron must be heated to a temperature much higher than that required for steel. This practice not only further increases fuel consumption, but also endangers the furnace itself and materially shortens its service life even though the best grade materials are used for its construction.

The slag formed during a commercially pure iron melt is unusually high in iron oxide content. The following typical analyses show the analytical differences between common steel slags and commercially pure iron slags:

	Commerically Pure Iron	*Common Steel*
Silica	10.06%	14.84%
Iron Oxide	40.43	18.21
Alumina	2.71	3.77
Calcium Oxide	32.66	45.66
Magnesium Oxide	6.17	8.92
Manganese Oxide	4.21	3.87

The extreme cutting action of this high iron oxide slag (augmented by the fact that an increased temperature is necessary that the iron pour properly) plays havoc not only with the furnace linings, but the ladle brick and sleeve brick as well. Using the best grade ladle brick it is necessary to reline the ladle every third or fourth heat, whereas 20 or more steel heats could have been poured without relining.

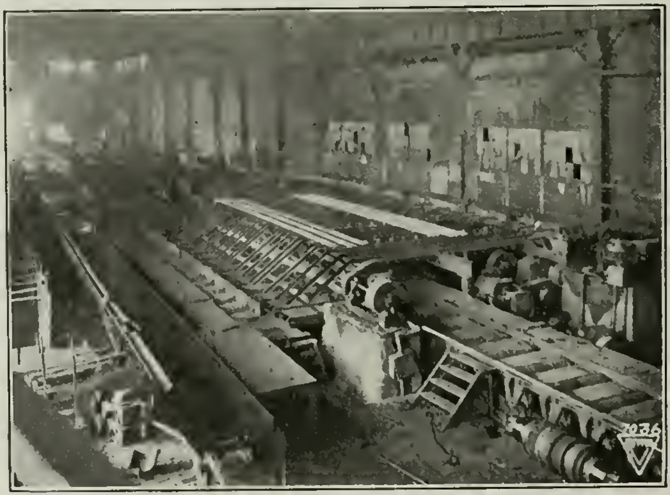


Fig. 3.

Fig. No. 1 illustrates this point very clearly. This is the view of a section of a stopper rod actually used when pouring a commercially pure iron heat. Two sections of a costly yet highly refractory brick of special design and quality were placed on the rod in order to compare them with the ordinary sleeve brick which covered the remainder. These sleeves, which the illustration shows have successfully withstood the action of the slag, were developed after many trials and a thorough comparison of various style sand qualities based on results of actual service experiments.

Each step in the manufacture of commercially pure iron has required scientific thought, study and experiment. The efforts of an efficient research organization have been essential factors in the development of the product. Another example typifying the need of research endeavor was the problem of degasification; in other words, the perfection of sound ingots so that, when rolled and fabricated, the metal would be sound and possess the very desirable qualities resulting when the iron is gas free. Fig. No. 2 (split ingots) illustrates how successful the degasification experiments have been and shows the sound commercially pure iron ingot in comparison with the usual unsound condition of the common steel ingot.

When ready to roll commercially pure iron, the manufacturers were confronted with another problem, namely, the fracturing and breaking of the metal when rolled at certain temperatures. Investigation disclosed the fact that commercially pure iron had a critical range within which it could not be worked. To overcome this rolling characteristic, it was necessary to again depart from usual manufacturing procedures.

The ingots when removed from the soaking pit are worked through the bloomers, cut in suitable lengths, and transferred to cooling racks (Fig. 3) where they cool down through the critical range. They are then removed from the rack, rolled to proper thickness, and sheared into standard sheet bar lengths.

Mention must be made of the skilled inspection to which each bar is subjected before it is declared fit for sheet rolling purposes. Only such bars as are entirely free from blemishes are permitted to pass to the sheet mill units. This step in the manufacturing process insures prime sheets which, after scientifically controlled annealing, are prepared for industrial use by such various finishing processes as are required in order that they conform to the rigid specifications demanded for quality sheets.

These described departures from the usual manufacturing processes do not tell the whole story of commercially pure iron production, yet the examples enumerated typify the procedure necessary to show clearly that each step in the entire production process is the result of careful planning, research investigation, and the elimination of such manufacturing procedures as may be suitable for ordinary iron or steel production but are inadequate when commercially pure iron is the desired product.

The Acid Electric Steel Process

Outline of an Article on This Subject Written by Albert Muller and Published in Stahl und Eisen—Various Metallurgical Reactions in This Process Are Recorded.

By R. J. WEITLANER

LOOKING through the technical literature pertaining to the manufacture of steel in the acid electric furnace, we find a great lack of information concerning this important branch of the steel industry. What little has come out in this respect is chiefly devoted to the melting practice, but very little light is thrown upon the various metallurgical reactions taking place in this process.

In view of the fact that the acid electric process plays such an important role in the steel foundry and will perhaps in the future become an adjunct to either the basic electric or basic open hearth, it may be opportune to give to American steel makers the outline of an article on acid electric steel by Albert Mueller as published in Stahl und Eisen of Jan. 15, 1914, to be followed later on by a discussion of acid electric melting as practiced in this country, as far as the writer's own experience with it is concerned or as far as it has come under his observation.

The above author deals with the refining of hot metal in a three-ton Girod Furnace, the hot metal was delivered from a basic open hearth or basic converter. He begins with a description of an acid furnace lining.

The hearth of the furnace was made with a mixture consisting of 80 per cent crushed, old silica bricks, 6 per cent fire clay and 14 per cent tar and rammed in as far as the slag lime, the side walls and the roof were made of silica bricks.

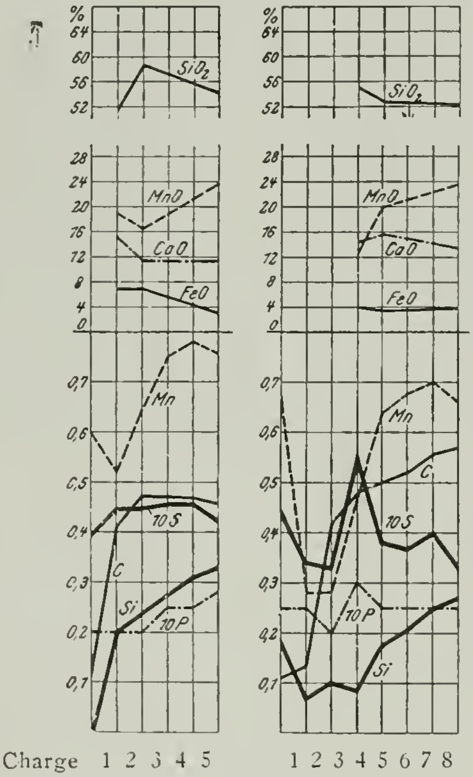
TABLE 1.

	Bottom			Side Walls	
Composition.	To start with. Basic.	To start with. Acid.	After 27 heats. Acid.	To start with.	After 27 heats.
SiO_2	5.72	80.50	64.60	95.30	83.50
CaO	46.50	4.30	12.90	1.85	3.55
MgO	27.60	1.91	2.90	Tr	.65
Al_2O_3	1.46	3.08	2,65	.58	.97
Fe_2O_3	1.85	.38	.43	.57	4.50
Fe O	.99	1.16	1.93	.26	3.65
Mn O	.40	.27	12.05	.19	2.36
P_2O_5	.09	.02	.02	.08	.08
Carbon	8.60	7.75	1.20	Not det.	Not det
Ignition Loss	14.35	7.80	.....	....	....

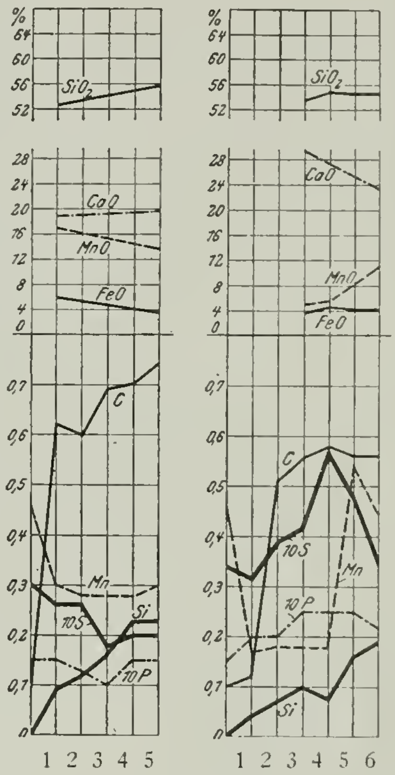
Table 1 illustrates the changes taking place in the composition of the hearth and side lining after a run of 27 heats, and gives for comparison the composition of a basic hearth. One may readily see to what large changes in composition the acid hearth is subjected, especially in regard to its content in silica as well as to CAO, MgO and the oxides of Fe and Mn, showing the marked influence of the reactions in the furnace upon the bottom material.

The carbon left in the hearth from the tar is usually absorbed after two heats, but whereas this carbon in the basic bottom has no part in the chemical reactions it plays a very important role in the acid furnace, reducing SiO_2 to a large extent, so that the first few heats show an excessive amount of silicon in the final product.

Tables 2 and 3 give the changes in the composition of steel and slags, also showing the various additions made during five heats and Figures 1 to 5 illustrate these results by means of curves.



Figs. 1 and 2
Heat Nos. E 24 and 25



Figs. 3 and 4
Heat Nos. 29 and 31

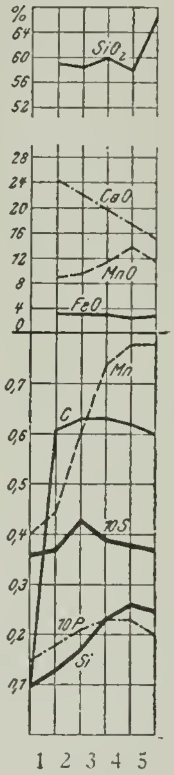


Fig. 5
Heat No. E 39

Reduction of Silica.

The examples given in tables and curves allow us to distinguish 4 separate phases of silica reduction, as follows:

(1) Continuous and almost exclusive reduction of SiO_2 from the hearth.

In a normal run and at normal temperatures the reduction of Si. will largely come from the silica of the hearth. (See heat 25.)

(1) Reduction of SiO_2 due to increased percentage of SiO_2 in slags.

An addition of silicious material (sand) to the slag results in a sudden increase of Si in the metal as seen from heats 29 and 39 making the slag sticky and pasty.

(3) Reduction of SiO_2 through increase in slag temperature.

Heat No. 24 shows a decrease of SiO_2 in the slag from 58.8 per cent to 54.4 per cent and a simultaneous increase of Si in steel of .1 per cent due to higher power input and resultant rise in temperature.

(4) Reduction of SiO_2 by carbon.
According to $SiO_2 + 2\,C = Si + 2\,Co$.

This reduction takes place during carburizing and will be noticed in heat No. 24 where with an increase in carbon of .30 per cent the silicon went up from .0 to .20 per cent.

All these reactions increase in intensity with an increase in temperature of steel and slag. The increase in Si is particularly noticeable in newly lined furnaces but after a longer run this phenomano becomes less important. As this reduction decreases in intensity the two most important reductions are presented by the degree of silicity and the temperature of the slag. We notice that these reactions are proportionately far more intense than similar reactions in an acid open hearth furnace or in the crucible process, whereas only one eighth of the SiO_2 is reduced in the latter.

The reduction of Si from the lining and the slag is the source of certain advantages inherent to the acid electric process one of which is found in the improvement of the quality of the steel and another in the greater economy, since additions of metallic Ferro silicon become unnecessary. It also causes a certain quietness during pouring, which is characteristic of acid electric steel and exerts a very favorable influence

TABLE 2—RESULTS OF HEATS.

Practice.	Test No.	C.	Mn.	P.	S.	Si.
Open Hearth metal 324		.12	.60	.020	.040	trace
40 lbs. petrol coke	1	.42	.52	.020	.045	.20
22.4 lbs. Ferro-manganese	2	.47	.64	.020	.045	.24
26.9 lbs. Ferro-manganese	3	.47	.75	.025	.046	.28
	4	.47	.78	.025	.046	.31
Final anal. of heat 24	5	.46	.76	.028	.043	.33
Open Hearth metal 330		.11	.66	.025	.044	.18
44.8 lbs. ore, slagged off	1	.13	.28	.025	.034	.07
44.8 lbs. petrol coke and electrodes	2	.42	.28	.020	.033	.10
44.8 lbs. Ferro-manganese	3	.48	.40	.030	.053	.09
22.4 lbs. Ferro-manganese	4	.50	.64	.025	.038	.18
6.7 lbs. Ferro-manganese	5	.52	.68	.025	.037	.21
	6	.56	.70	.025	.040	.25
Final anal. of heat 25	7	.57	.66	.025	.034	.27
Open Hearth metal 360		.09	.46	.015	.030	trace
62.7 lbs. petrol coke	1	.62	.30	.015	.026	.09
3 shovels of sand	2	.60	.28	.013	.026	.12
Petrol coke to reduce	3	.69	.28	.010	.018	.16
MnO in slag	4	.70	.28	.015	.020	.23
Final anal. heat 29	5	.74	.30	.015	.020	.23
Open Hearth metal 383		.10	.45	.015	.034	trace
134 lbs. ore, slagged off	1	.12	.17	.020	.032	.04
49 lbs. petrol coke and electrodes	2	.51	.18	.020	.039	.07
Test red short	3	.56	.18	.025	.042	.10
Test red short	4	.58	.18	.025	.057	.08
44.8 lbs. Ferro-manganese	5	.56	.54	.025	.048	.16
Final anal. of heat 31	6	.56	.44	.022	.035	.19
Open Hearth metal ?		.09	.40	.015	.036	.10
54 lbs. petrol coke	1	.61	.44	.018	.037	.13
22.4 lbs. Fe Mang	2	.63	.60	.021	.043	.17
33.6 lbs. Fe Mang—3 shovels sand	3	.63	.74	.023	,039	.23
4 shovels sand	4	.62	.78	.023	.038	.26
Final anal. of heat 39	5	.60	.78	.020	.037	.25

TABLE 3—CORRESPONDING SLAG ANALYSIS.

Heat No.	Test No.	SiO_2	CaO	MgO	Al_2O_3	Fe_2O_3	FeO	MnO	S	P_2O_5	O in base / O in acid
24	I	51.50	15.30	3.80	2.60	...	6.95	18.85	.25	.01	
	II	58.80	11.40	4.30	2.14	...	6.85	16.30	.27	.03	
	V	54.00	11.50	5.20	1.72	...	3.35	23.55	.29	.03	
Oxidiz slag		39.02	5.80	1.50	1.92	2.15	23.80	25.41	.15	.20	
25	III	54.84	14.50	...	...	...	3.85	12.66	.20	...	
	V	52.70	15.80	...	...	...	3.60	20.15	.12	..	
	VII	52.60	13.70	3.20	1.52	...	3.85	23.70	.13	.12	
29	I	52.50	18.75	2.90	1.36	...	5.80	16.70	.11	.05	
	V	55.80	19.60	4.02	2.02	...	3.55	13.85	.03	.03	1/3
Oxidiz slag		45.10	5.35	2.10	1.75	2.30	23.65	19.30	.40	trace	1/2
31	III	53.50	29.60	3.10	1.49	.43	3.60	4.95	.37	trace	
	IV	55.20	not det.	...	...	...	4.35	5.70	..	..	
	V	54.20	not det.	...	...	...	4.25	8.35	..	...	
	VI	54.20	23.20	3.05	1.86	.35	4 05	11.15	.40	trace	2/3
39	I	58.83	24.29	2.40	1.75	.29	3.07	8.93	.39	trace	
	II	58.54	not det.	...	...	...	2.96	9.59	..	..	
	III	59.78	not det.	...	...	...	3.08	11.45	..	..	
	IV	57.92	not det.	...	...	...	2.58	13.79	...	..	
	V	66.27	15.26	2.03	.15	...	2.81	11.68	.51	..	1/4

upon the micro structure and grain size of the finished product.

According to Thallner, Geilenkirchen & Eilender, the continuous action of reduced silicon upon the metal must need be preferable to the addition of silicon in its solid state, as it is not liable to leave behind products of oxydation, in the form of silicates of iron and manganese which may not have time to rise to the surface and are liable to make their appearance in the final product as sand spots, etc. The action of silicon in its nascent state as we may say, will naturally be more beneficial in destroying oxides, emulsions and gases than solid silicon.

Sulphur.

Besides the various reactions of silicon in the acid electric process, the next important element to be considered is the sulphur.

A glance at the heat curves and charts reveals the interesting fact that in almost all these heats the sulphur shows a marked variation throughout the operation finally resulting in a slight decrease.

If we first consider the oxydizing stage of a melt we will note a slight decrease in sulphur which is most probably caused by the reaction $FeS + 2\ FeO = 3\ Fe + So_2$.

This oxydation of S to So_2 also occurs in the puddle process and in the oxydizing stage of the basic electric furnace. This is particularly manifest in heat No. 25 and to a minor degree in other cases where the FeO content of the slag was less marked and where the temperature was possibly lower. Considering now the second, or refining part of the process another explanation must be sought to account for the fact that the percentage of sulphur in the metal is not only maintained but in some cases decreased.

It should be borne in mind that in adding petrol coke considerable quantities of sulphur (see heats Nos. 25 and 31) were introduced into the metal and as the tests taken did not correspond in time with these additions, the apex of the sulphur line would be considerably higher than the one shown by the curves (see Figs. 2 and 4). The actual amount of sulphur contained in 62.7 lbs. of petrol coke added in heat No. 29 was 170 grams, corresponding to .01 per cent S in the bath, most of which must have been dissoved by the steel and then again been eliminated in the course of the melt.

We are therefore justified to speak of a desulphurization in the acid electric furnace.

How does desulphurization in an acid electric furnace take place?

In the basic electric process desulphurization is carried out under a strongly basic and reducing slag after all the oxides of iron and manganese have been reduced according to:

$$3\ FeS + 2\ CaO + Ca\ C_2 = 3\ Fe + 3\ Co\ S + 2\ CO$$

We are not only able to obtain slags in the acid furnace which are practically free from oxides but may even observe the formation of calciumcarbide from the lime and carbon added.

On account of the low percentage of lime however and the presence of considerable MnO in these acid slags we cannot speak of a desulphurization according to above equation. This is shown by the fact that the CaS content of the slag is not appreciably higher in the final slag test. Therefore we must conclude that sulphur is reduced thru formation of the volatile sulphur silicide SiS_2, a reaction which also occurs under the electric are of the basic electric process.

In regard to the elimination of phosphorus which can be carried out so completely under a basic oxydizing slag in the basic electric furnace, this of course cannot be done in the acid process. Any phosphates of iron would be decomposed by the excess of silica, the phosphorus being reduced back into the bath. Curves 1 to 5 show a slight increase of this element due to metallic additions made at the finish of the heat.

Furnace Practice.

In conformity with the acid lining an acid slag has to be carried, which, with a cold charge will form itself through combination of iron and manganese oxides with the impurities of the charge and through oxidation of silicon. As the furnace in discussion, however, was always charged with hot metal, additions of silicious material were necessary to cover the bare bath.

We can, like in basic process distinguish between oxydizing and reducing slags the former being the iron-manganese silicate slag, has great similarity with the corresponding slag of an acid open hearth, whereas the latter is peculiar to the acid electric furnace only.

Looking at the composition of two oxydizing slags (heats 25 and 31) we note that on account of a greater basicity of the slag in heat 25 a greater destruction of the hearth will and actually did take place. It is therefore advisable to work towards a more silicious slag of lower MnO percentage as shown in heat No. 31. After removal of the oxydizing slag, a practice which is only required for certain grades of steel the reducing slag mixture consisting of 75 per cent crushed silica bricks and 25 per cent burned lime is thrown on which melts quickly without any addition of fluxes.

As seen from analyses the composition of the acid slag varies considerably and is subjected to great changes during the ensuing melting.

Special care has to be taken in the regulation of these slags in order to obtain the proper finishing slag necessary for a satisfactory material.

The degree of heat has, according to Thallner, a decisive influence upon the slag.

With the low temperature, at the beginning of deoxidation we obtain mostly dark gray or more or less glassy slags on account of high iron oxide content. With increasing temperatures however, the color of the slag turns lighter, becomes porous and finally liquid. With the beginning reduction of iron oxides and a corresponding increase in MnO the glassy mass turns into a light gray. According to various percentages of MnO we obtain green slags of all shades. With a higher lime content for instance 30 per cent CaO, 5 per cent MnO, 54 per cent SiO_2 and 4 per cent FeO the slags appear gray and even desintegrate when exposed to air. Those that contain 55 per cent SiO_2, 32 per cent CaO, 8 per cent MnO and 2 per cent FeO are of a blue color and reveal, when fractured, a structure similar to volcanic lava. These various intermediate slag stages can, with proper addition and temperature regulation be converted into a liquid, greenish-yellow finishing slag, under which the refining and settling of the bath is to be carried out.

The fact that on the one hand basic constituents of an acid slag react destructively upon the lining but that on the other hand a highly solicious slag remains too viscuous, requires a certain basicity of the slag. While oxydizing acid slags show a ratio of 1:2 for the oxygen in the bases to the oxygen in the acid constituents, we may have as high a ratio as 1:4 for reducing conditions(see heat 39). This is however unusual and only permissible for certain grades of steel and it is therefore desirable to decrease the oxygen in the acid resulting in a lowering of its melting point. The means to obtain these conditions are additions of lime and magnesia.

The percentage of lime is best kept around 15 per cent, as 20 per cent in the slag acts deteriorating upon the lining. An increase in Magnesia also increases the basicity and liquidity of the slag. MgO content should be between 2 per cent and 5 per cent. It is advisable to keep the magnesia down to this percentage and to regulate the basicity of slags by means of MnO. This can easily be done by addition of crushed Ferro-manganese as seen in heat 39. A further increase of MnO above 10 to 15 per cent may result in throwing back of manganese into the bath through reducing agents like coke, etc. Such was the case in heats 29 and 39 where the addition of a shovel of petrol coke reduced 2.85 per cent and 2.11 per cent MnO in a very short time.

The presence of such percentages of MnO are characteristic of a reducing acid electric furnace slag in comparison to basic reducing slags in which the MnO content is practically nil. Less difficult than the reduction of MnO is that of iron oxide, its percentage being much lower than that found in acid open hearth slags and forming another characteristic of an acid deoxidizing practice. The iron oxide content varies usually between 7 and 2 per cent being higher at the beginning of the reducing period and can easily be decreased through addition of free carbon.

The reduction of FeO in the slag is partly caused by the continuous action of the electrode carbon upon the slag, its percentage usually coming down to between 3 or 4 per cent.

A further reduction of FeO is obtained by adding carbonaceous material such as coke and can be carried out to an extent practically equal to that of a final basic slag (see final slag of heat 39). No particular advantages could however be gained.

When comparing these final slags with those of the acid open hearth, in which the SiO_2 remains close to 50 per cent and very rarely exceeds 55 per cent we note, that in "acid electric furnace melting" the SiO_2 is generally between 55 to 60 per cent.

Should however the SiO_2 increase any further we obtain slags of high melting point, as seen in heats 39 with 66 per cent. SiO_2 requiring addition of fluxes to thin out and to restore their capacity for reactions. It is therefore best to regulate the slags so as to obtain a ratio of basicity of 1:3.

The author in conclusion favors the adoption of the acid electric furnace process in preference to the basic, in such steel plants where hot metal of reasonably low percentage in S. & P. is available and where the final product comes within specified requirements in these elements. During a long run in this particular steel plant, and without particular care in the selection of open hearth charges, the average phosphorous content of the acid electric heats was .020 per cent and the sulphur showed an average of .035 per cent.

These low percentages of S. & P. have of course no harmful effect upon the physical properties of the steel. Of greater importance upon the quality of the product is the care during melting and finishing of the heats, the proper slag conditions and temperatures of the bath which exert a decisive influence upon the micro structure of the steel. The temperature during refining has according to Thallner, a marked influence upon the crystalline structure and hence upon the shaped product.

Proper melting and refining in the acid furnace is however not as easy as may perhaps be imagined, requiring technical ability and experience as well as metallurgical knowledge. The desirable formation of silicon in its nascent state does not constitute in itself a superiority over other processes. The author summarizes the economical advantages offered by this process when compared with the basic process as follows:

(1) Less current consumption due to shorter melting time. The duration of a heat is shortened as the oxidizing period is in most cases eliminated. The deoxidizing period, being continuous and intenser in degree than in the basic process, can therefore be carried through in a shorter time.

(2) Saving in deoxidizers, the silicon being obtained from lining and slag as outlined before.

(3) Less lining, repair and maintenance cost, on account of the lower price of the acid material when compared with basic refractories, such as magnesite, etc.

(4) The cost for furnace additions in the acid furnace are almost nil, as the final slags can, with advantage be used over again.

Resume.

The acid electric furnace process offers economical as well as metallurgical advantages to such steel works which have at their disposal a metal low enough in phosphorus and sulphur to come within given specifications. The process is also limited by the silicon reactions resulting in a silicon content unsuitable for certain grades of steel.

Appendix.

In addition to the article by the above writer, I may quote O. Thallner, Stahl und Eisen, 1910, p. 1348, who predicts that in the near future it will be possible to eliminate sulphur more thoroughly in the acid electric furnace.

Eilender in Stahl und Eisen, 1913, p. 585, presents curves, showing a much lower power consumption for the acid than for the basic electric furnaces. The greater intensity of the reactions and the lower heat conductivity of acid refractories is given in explanation of this fact. The quality of the steel is said to be mainly dependent upon the size of the molecules in the molten stage, the smaller the latter the better the quality of the steel. Even for best grades higher sulphur and phosphorous limits are allowable.

THE FATIGUE OF METALS.

Professor H. F. Moore addressed, probably one hundred members of the Pittsburgh Chapter of the American Society for Steel Treating on the evening of December 6, at the Hotel Chatham, on the subject of his recent investigation, "The Fatigue of Metals." His discussion was so beautifully clear and concise, so nicely interspersed with every day examples of the thought he wished to express, that we cannot do otherwise than imagine that his ability to present an easily understood story to his audience has been acquired by much experience in teaching.

As his report will be distributed in bulletin form by the University of Illinois in the near future, attempt to set forth here any part of his address would be useless other than to say that he found in the tests which they have made that the Brinnell hardness might be used in predicting the approximate value of the endurance limit. The other physical properties apparently bear no relation to the endurance limit with the possible exception of the ultimate strength. Prof. Moore does not attempt to explain this apparent relationship or lack of relationship. We admire his frankness in admitting inability to account for this proportionality. This absolute candidness coupled with his lucid explanation of the tests conducted and his discussion of the results obtained combined to make the evening most profitable.

The next meeting of the Pittsburgh Chapter will be addressed by Prof. A. E. White of the University of Michigan and past-president of the American Society for Steel Treating.

Open Hearth Furnace Makes a Record

McKune System Furnace Installed at the South Works of the Illinois Steel Company Shows Remarkable Speed and Efficiency.

THE McCUNE type of furnace has worked a radical change in the construction and operation of Open Hearth Furnaces. Remarkable results have been obtained in increased production per furnace unit and decreased cost of operation per ton of product.

In making a comparison between the construction and operation of the ordinary Open Hearth Furnace as compared to one of the McKune type, we find that in the ordinary construction the furnace ports are necessarily built of large area to provide for the exhaust of the waste gases of the furnace. Such large port areas are contrary to the requirements of the incoming air and fuel. To obtain a rapid mixture of the air and fuel and therefore the best combustion, much smaller areas should be used. Because of the large port areas necessarily used in the furnace construction for exhaust purposes, the Open Hearth operator in the past has failed to realize the much higher efficiency obtainable through a more rapid mixture of the air and fuel, coincident with the use of small port areas.

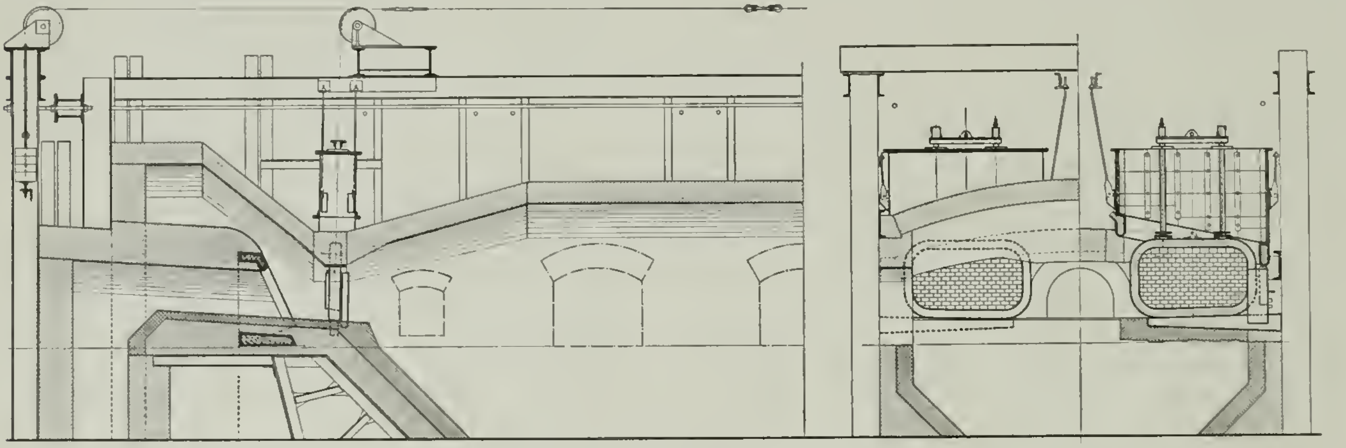


Fig. 1—Section through McKune furnace.

The McKune type of furnace was first developed at the Steel Company of Canada, Limited, by Mr. F. B. McKune, Open Hearth Superintendent. At this plant a by-product coke installation was put into operation in 1919, and because of the high price of other fuels it was highly desirable to use the surplus coke oven gas as fuel for the Open Hearth. Wherever coke oven gas had previously been adopted as Open Hearth fuel, it was in combination with liquid fuel, such as oil or tar, the high velocity of the atomized liquid fuel being used to control the very light coke oven gas. The use of coke oven gas alone had, after numerous trials, been given up as impractical. At the Steel Company of Canada the use of debenzolized coke oven gas became a necessity, which resulted in the conception and development of the McKune type of furnace.

The governing principle of the McKune construction is to provide the means of having a small incoming port and a large outgoing port. The method of operation is to provide a high velocity to the incoming air so as to drive it into quick mixture with the fuel in order to obtain a rapid combustion similar to that of the blow-torch flame, and a flame well directed onto the materials being heated and melted, and to exhaust the waste gases at a low velocity through the outgoing port. A fan is used to force the air supply through the restricted port area. Mr. McKune perfected this method of operation in the winter of 1919 and 1920, obtaining a large increase in production per furnace with a corresponding decrease in the amount of fuel used per ton of product. Because the flame was well-directed to the furnace charge and away from the furnace walls and roof and on account of the low velocity of the outgoing gases, the life of the furnace was very much prolonged and the cost of the furnace maintenance reduced. These results soon became generally known and attracted the attention and interest of progressive Open Hearth managements. They have come to realize that in order to obtain the maximum production and economy, the Open Hearth port construction and operating methods of the past must give way to new construction and operation.

With the port areas controlled by the damper arrangement as devised and developed by Mr. McKune for coke oven gas, natural gas or liquid fuel can be equally well utilized with the same improvement in production and economy compared to past practice. Inasmuch as the greater number of Open Hearth furnaces are operated with producer gas an equivalent arrangement was necessary to be developed for this fuel. In the past construction of Open Hearth furnaces the use of producer gas has entailed a more complicated port construction compared to that necessary for the other fuels and it was not an easy matter to develop the application of the McKune principle for producer gas without complicating the port design.

However, George L. Danforth, Jr., and his associates have developed a port construction and controlling damper arrangement as simple, effective and durable as for the other fuels. Furthermore, with this adaptation any fuel can be used equally as well by simply providing an ordinary means of supplying the other kinds of fuel to the port used for the introduction of the producer gas. When fuel other than producer gas is being used with this arrangement, the gas generators and passageways would be used for the introduction of approximately one-half of the air supply.

As shown by Figure 1, two dampers are used on each end of the furnace. On the incoming end of the furnace the two dampers are lowered into the port area several feet in front of the gas port mouth, providing a central passageway approximately one-third of the total throat area. This small area makes it possible to obtain a comparatively high velocity to the air which drives it into a more rapid mixture and combustion of the fuel, providing a much shorter and hotter flame than it is possible to otherwise obtain. The dampers on the incoming end are counterbalanced by means of sheaves and cables with those of the outgoing end which are drawn up through the low roof knuckle into a brick lined box, leaving the total area of the throat available for the waste gases exhausted at a low velocity. This provides a better passageway for the outgoing gases than provided for in the port of an ordinary type of furnace, as there is no block for the outgoing gases to pass over and make a hairpin turn down the downtakes.

The low knuckle of the roof coupled with the absence of any port block keeps the waste gases traveling across the melting chamber at a lower elevation, and in better contact with the bath. With this arrangement, as compared to that of an ordinary furnace there is obtained a material improvement both to the incoming and outgoing end of the furnace, resulting in a much faster and more efficient transfer of heat to the materials being treated. Because of the comparatively short flame with its better direction, the life of the entire furnace brickwork is materially prolonged.

A producer gas furnace as just described was installed at the South Works of the Illinois Steel Company about July 1, 1921. After a few days of operation, required for properly adjusting the air supply and other operating devices of the new arrangement, the furnace began to show remarkable speed and efficiency. The hearth dimensions of this furnace are as follows:

> 32 feet long by 13 feet 3 inches wide, giving a hearth area of 424 square feet, equivalent to that of an ordinary fifty-ton furnace.

There was produced in this furnace in the month of August, 1921, 105—76.5-ton heats for a total of 8,020 gross tons with 400 pounds of coal per ton of ingots. In a later period of thirty-one days, there was produced 106—85.5-ton heats for a total of 9,053 tons, with 348 pounds of coal. In the three-month period, August 1st to November 1st, the furnace was operated 85½ days and made 268—80.8-ton heats for a total of 21,670 tons, with 413 pounds of coal. A straight Open Hearth charge of 50.8 per cent hot metal 43.8 per cent scrap and 5.4 per cent metals from ores was used. This is by far the most remarkable performance ever accomplished on an Open Hearth furnace and the tonnage from this 50-ton hearth is believed to be considerably more than was ever produced on much larger furnaces for any equivalent period of time.

Mention has been made of the comparatively long life of the furnace. At the time of writing this article, the furnace is still in operation, having produced 417 heats for a total production of 33,000 tons. Experience with this furnace has shown that the operation in the latter part of the furnace life will be more equal to that of the first part than is true with the past construction, for the dampers maintain the correct area of the incoming port throughout the campaign and on account of the comparatively short flame and the low velocity of the outgoing waste gases, the furnace checker work remains much freer of deposit and the furnace draft is corrrespondingly improved over that of the ordinary type. Although having produced over 33,000 tons of steel, the furnace is still producing approximately 1350 tons of steel per week which is beyond the possibilities of the average Open Hearth furnace even when new and at its best.

The following table conservatively exhibits the relative production and cost of operation of this type of furnace compared to the ordinary type:

	Ordinary Type.	McKune Type.
Representative Hearth Area.....	500 sq. ft.	500 sq. ft.
Representative Size of Heat....	80 tons	80 tons
Maximum Production per Month	6,000 tons	9,000 tons
Average Production per Year...	48,500 tons	72,750 tons
Excess Production per Year	....	24,250 tons
Cost of Operation per Ton.....	$4.50	$ 3,50
Annual Savings at $1.00 per Ton		72,750.00
Subtract First Cost of Equipment		12,000.00
Net Saving First Year......		60,750.00

The excess production of 24,250 tons per year would otherwise have to be provided by additional installation at an approximate cost of $200,000.00.

It can be readily understood that in addition to the large savings made in the cost of operation, the large production per furnace unit provides a great saving in the cost of installation per ton of product. Steel companies from time to time find it necessary to provide more Open Hearth producing capacity. This increase has been made in the past by providing more furnace units at a capital expenditure ranging from $7.00 to $10.00 per ton of annual capacity. A large increase in capacity can now be met by reconstructing the present furnaces to the McKune type, at a very nominal cost.

Open Hearth operators realize that with the hotter, faster-working furnace and the better control of the flame, a higher grade of steel is produced. The steel made during the record performance of the aforesaid furnace was applied to high grade orders such as seamless tube rounds, fire-box plate, and the general run of mill orders. A great many visiting Open Hearth men interested in the operation of this type of furnace were present during some part of the time in which the records given above were made, and were naturally interested in seeing the finished production of the steel from this furnace. They stated without exception that it was above the general run of Open Hearth product.

The governing principles employed in the McKune furnace and the several specific arrangements for utilizing these principles, are fully protected by patents either issued or pending. These patents are owned by the Miami Metals Company, of Chicago, Illinois. The Blaw-Knox Company, of Pittsburgh, Pa., have been made their sales agents for McKune furnace installations.

Graphical Treatment of Stack Gas Analysis and Fuel Gas Analysis

Charts Calculated for Stack Gas Analysis for Producer Gas, Natural Gas, By-Product Tar, Coke Oven Gas, and for Coal—Wa. Ostwald Introduced These Graphic Charts.

By W. TRINKS

TO ANYONE but a chemist, there seems to be a more or less deep mystery connected with a stack gas analysis or with a producer gas analysis. The mystery deepens, if calculations are required for checking an analysis for accuracy or for finding excess or deficiency of air.

These conditions, which seem to be the same the world over, prompted Wa. Ostwald, the well known German chemist, to devise methods for graphically representing the relations between the various factors of the products of combustion of hydrocarbons. The results of his efforts are laid down in a little book called "Beitrage zur graphischen Feuerungstechnik" (Notes on graphical Combustion Engineering) which was published by Otto Spamer, Leipzig, in 1920.* In this work, Ostwald spreads himself from flue gas analysis to a graphical theory of the gasification in the gas producer, and even gives a graphical system of all hydrocarbons.

The book has been very fruitful. The ideas of Ostwald were taken up by others and were amplified and enlarged upon in articles which have appeared in the "Zeitschrift des Vereins Deutscher Ingenieure," "Stahl und Eisen," and in "Feuerungstechnik."

As far as the author knows, Ostwald's efforts are not well known in English speaking countries. For that reason, the most important phases of the work are given in the present contribution.

(1) Flue Gas or Stack Gas Analysis.

This part of the article follows, in the main, the derivations given by Mr. Seufert in the Z. d. V. D. I. 1920, page 505.

The purpose of any flue gas analysis is to show a) the carbon-dioxide (CO_2) content, b) the oxygen (O_2) content, c) the carbon-monoxide (CO) content, and d) the excess or deficiency of air. The use of the term "excess air" leads to cumbersome equations. For that reason, Ostwald prefers the air ratio **n**, which equals the ratio of the theoretical volume of air to the volume of air actually used.

If the composition of the fuel is known, any two of the four values a), b), c) or d) determine the other two. All four quantities can be shown in a triangle by the use of two superimposed systems of coordinates, or they can be represented in an alignment chart. Only the triangle method will be given in this article. The facts underlying the calculations for the construction of the triangle will now be given.

I. **Method for Solid and Liquid Fuels.**

The calculations are simplified by considering carbon to be in the gaseous state, and computing its specific volume from the relation: Molecular weight × specific volume = a constant, which is called the volume of one mol. Molecular weight of air = 29; specific volume of air at 32 deg. F. and 30" barometer = 12.4; 29 × 12.4 = 360; molecular weight of carbon = 2 × 12 = 24; equivalent specific volume of carbon $= \frac{360}{24} =$ 15 cubic feet per pound.

Let one pound of fuel contain c_1 pounds of carbon (C), h_1' pounds of hydrogen (H), q_1 pounds of oxygen (O). Then it contains $h_1 = (h_1' - q_1/8)$ pounds of available hydrogen. (Of the total hydrogen, a part is considered as combined with 8 times its own weight of oxygen, already present in the fuel—hence it does not require any oxygen from the air to burn it.) Sulphur and nitrogen in the fuel have no effect upon the gas analysis, and are, therefore, neglected.

a) Reactions for complete combustion without formation of carbon monoxide (CO).

Water vapor is not considered, because it disappears in the dry stack gas analysis. It should be kept in mind that the stack gas analysis is a **volume analysis**, whereas the analysis of solid and liquid fuels is a weight analysis; also that the volumes calculated are **equivalent** volumes, which the gases would have at 32 deg. F. and 30" barometer, if they were perfect gases following the law: absolute pressure × volume = constant × absolute temperature. As water vapor, the only product of combustion which departs far from this law, disappears in the analysis, this procedure is correct.

1) $C_2 + 2O_2 = 2\,CO_2$, which means that
   1 (equivalent) cu. ft. C_2 requires 2 cu. ft. O_2, and produces 2 cu. ft. CO_2.
   1 pound of C_2 requires 2 × 15 cu. ft. O_2, and produces 2 × 15 cu. ft. CO_2.
   c_1 pounds C_2 require $30c_1$ cu. ft. O_2, and produce $30c_1$ cu. ft. CO_2.

2) $2\,H_2 + O_2 = 2\,H_2O$, which means that
   1 cu. ft. H_2 requires .5 cu. ft. O_2.
   1 pound H_2 requires .5 × 178. cu. ft. O_2.
   h_1 pounds H_2 require 89 h_1 cu. ft. O_2.

Hence, theoretical volume of O_2 for 1 pound of fuel $= O_{min} = (30\,c_1 + 89\,h_1)$ cu. ft. Actual volume of oxygen, O_a, when the air ratio is **n**, (from $O_{min} : O_a = n : 1$), is $O_a = \frac{1}{n}\,O_{min}$. But each volume of oxygen

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*This book may be obtained from G. E. Stechert & Co., 151 West 25th St., New York City.

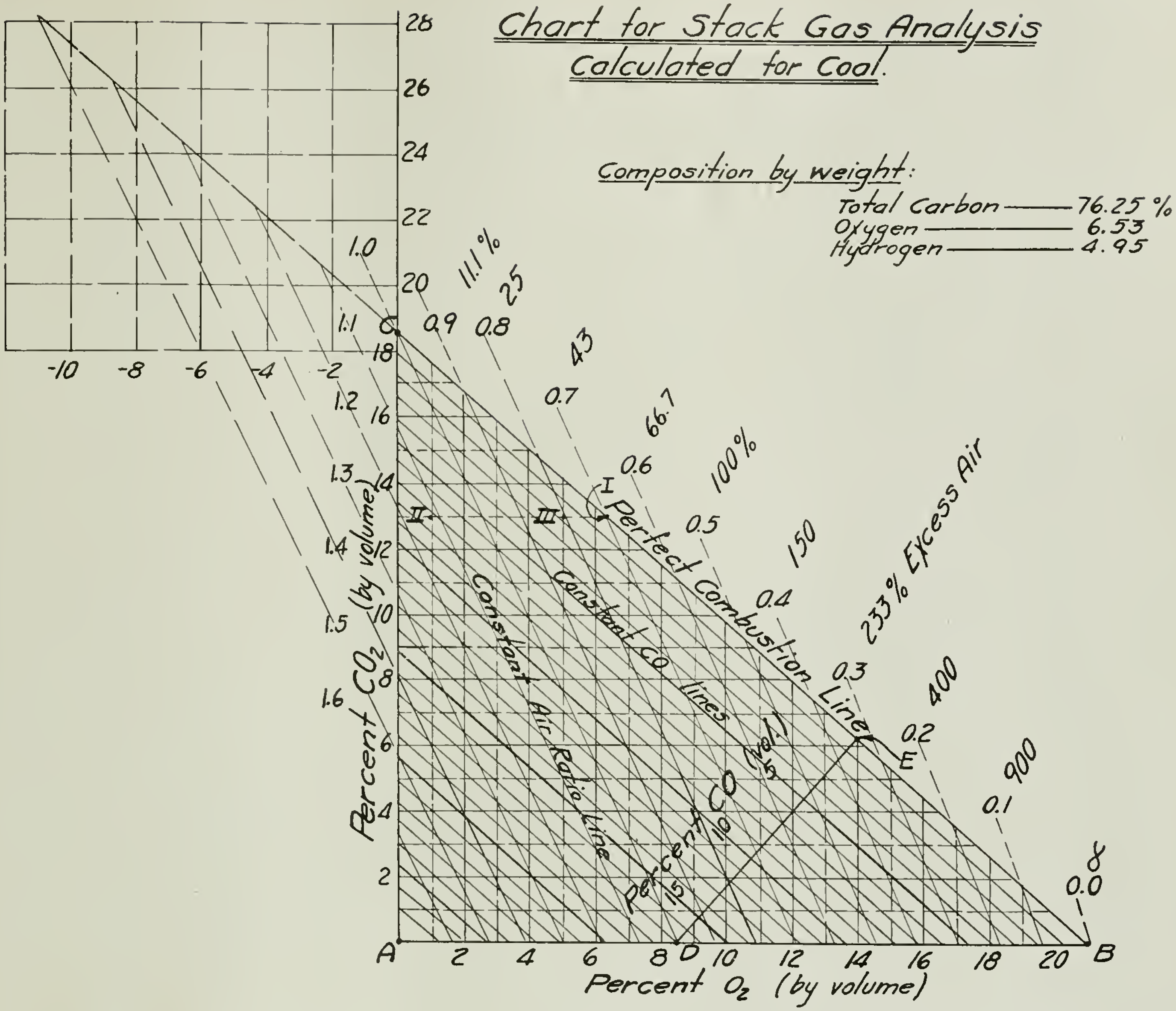


Fig. 1.

from the air carries with it $\frac{79}{21}$ volumes of nitrogen; hence stack gas volume for 1 pound of fuel is:

$CO_2 = 30\ c_1 = k$ per cent of stack gas volume

$+ N_2 = \frac{79}{21}\,\frac{1}{n}\,O_{min}$

$+$ excess $O_2 = \frac{1}{n}\,O_{min} = q$ per cent of stack gas volume.

Water vapor does not appear in the analysis.

From the above follows:

CO_2 content $= k =$

$$\frac{30\ c_1 \times 100}{30\ c_1 + \frac{79}{21} \times \frac{1}{n} \times O_{min} + \frac{1}{n}\,O_{min} - O_{min}}$$

$$= \frac{3000\ c_1}{30\ c_1 + O_{min}\left(\frac{4.76}{n} - 1\right)}$$

O_2 content $= q =$

$$\frac{O_{min}\left(\frac{1}{n} - 1\right)\ 100}{30\ c_1 + O_{min}\left(\frac{4.76}{n} - 1\right)}$$

These values, calculated for various values of **n**, furnish the corresponding points of the straight line CB in Fig. 1. Points on this line represent complete combustion—carbon burned to CO_2, hydrogen burned to H_2O.

b) Incomplete combustion of carbon, without formation of any CO_2, but with complete combustion of hydrogen.

1) * * * $C_2 + O_2 = 2\ CO$, which means that
1 (equivalent) cu. ft. C_2 requires 1 cu. ft. O_2, and produces 2 cu. ft. CO.
1 pound C_2 requires 15 cu. ft. O_2, and produces 2×15 cu. ft. CO.
c_1 pounds C_2 require 15 c_1 cu. ft. O_2, and " 30 c_1 cu. ft. CO.

2) * * * Combustion of hydrogen is the same as in (a 2).

The theoretical volume of oxygen for incomplete combustion of one pound of fuel is $O'_{min} = 15\,c_1 + 89\,h_1$, and actual oxygen volume $O_a = \frac{1}{n} O_{min}$, as before. The stack gas volume for one pound of fuel then is [$CO = 30\,c_1 = p$ per cent of dry stack gas volume] + [$N_2 = \frac{79}{21}\frac{1}{n} O_{min}$] + [$O_2 = \frac{1}{n} O_{min} - O'_{min} = q$ per cent of gas volume].

CO content = p =

$$\frac{30\,c_1 \times 100}{30\,c_1 + \frac{79}{21}\frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O'_{min}}$$

$$= \frac{3000\,c_1}{30\,c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

O_2 content = q =

$$\frac{\left(\frac{1}{n} O_{min} - O'_{min}\right) \times 100}{30\,c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

Calculation of q with the before-used values of **n** furnishes the points on the axis of abscissae AB, Fig. 1; (no CO_2, all carbon burned to CO). Those points of AB and of CD which belong to equal values of **n** furnish the lines of equal air ratios. The CO division is preferably marked on the line DE, which is drawn perpendicular to CB, passing through that O_2 point of line AB, for which **n** = 1.

A numerical example will make the method clearer. Let the fuel be Pittsburgh coal of the analysis:

Total carbon	76.25 per cent
Oxygen	6.53 per cent
Hydrogen	4.95 per cent

(a) Complete combustion—calculation for points on line CB.

CO_2 content = k =

$$\frac{3000\,c_1}{30\,c_1 + O_{min}\left(\frac{4.76}{n} - 1\right)} \text{ from above.}$$

$c_1 = .7625.$

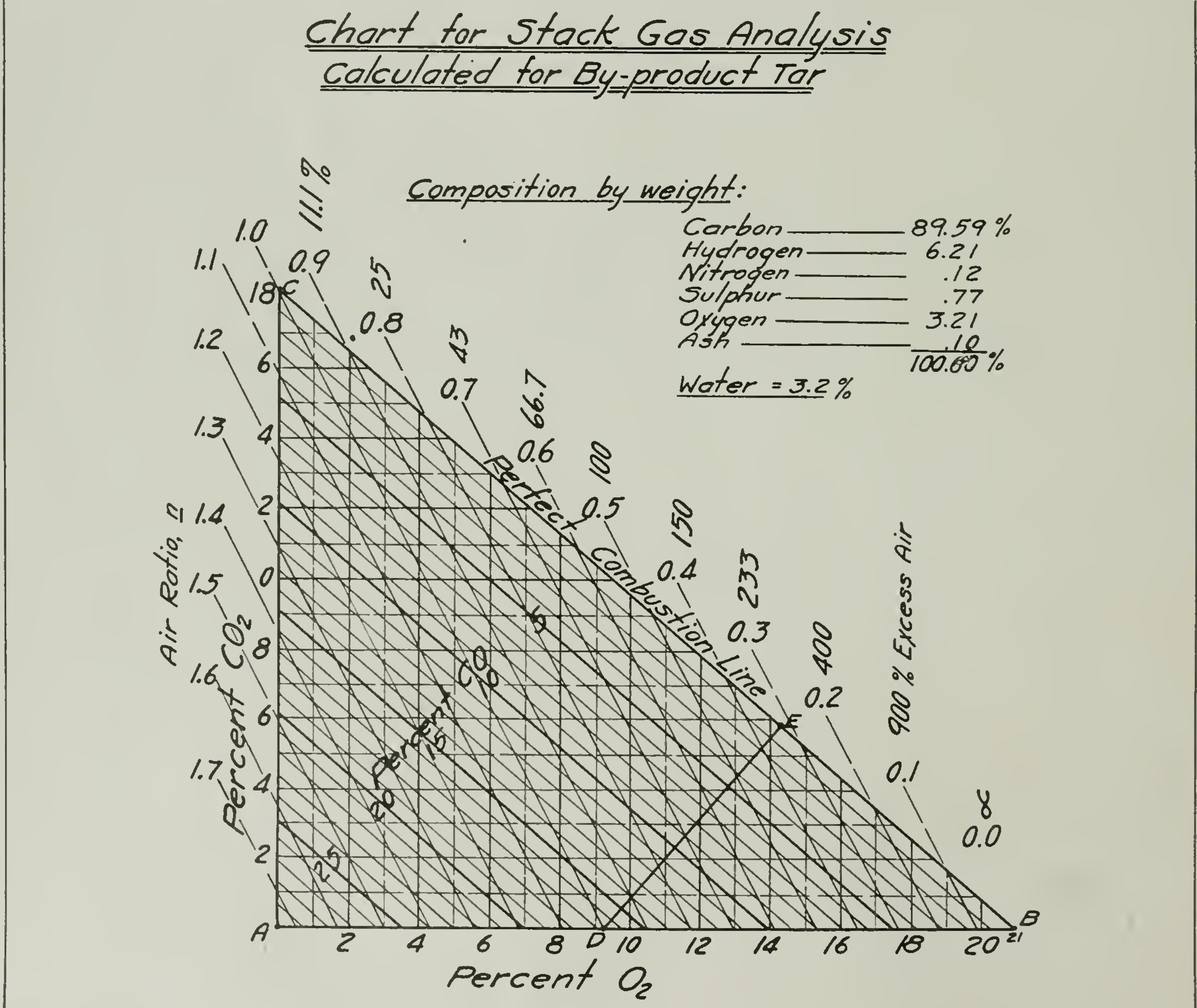


Fig. 2.

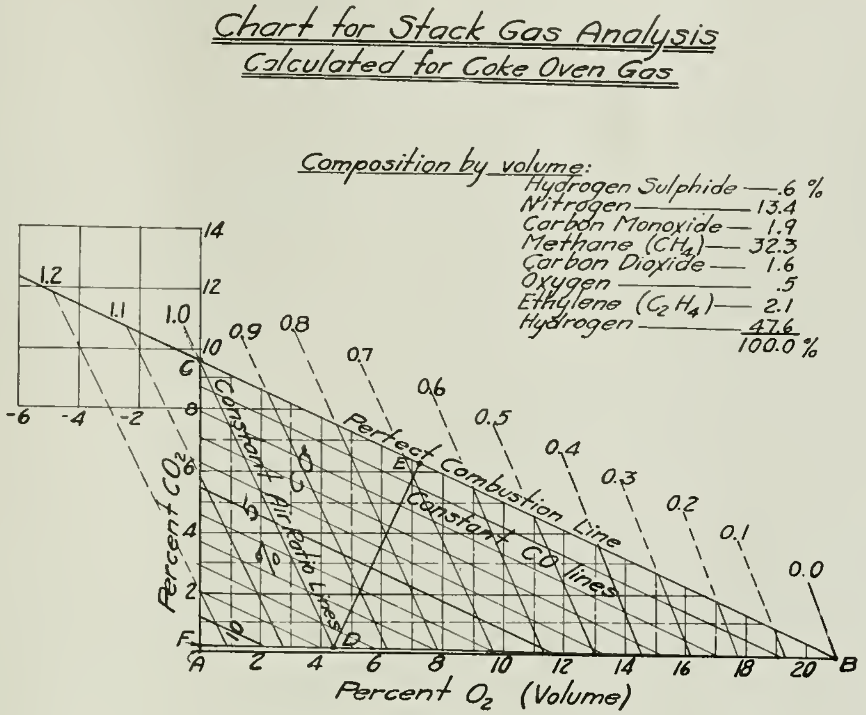


Fig. 3.

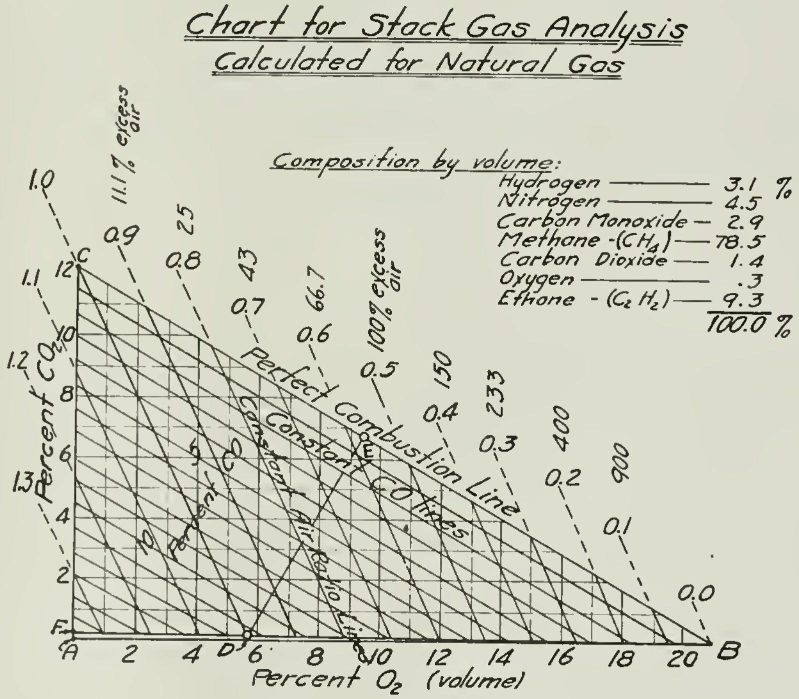


Fig. 4.

$O_{min} =$

$$30 \times .7625 + 89\ (.0495 - \frac{.0653}{8}) = 26.55 \text{ cubic}$$

feet of O_2 per pound of coal.

$k =$

$$\frac{3000 \times .7625}{30 \times .7625 + 26.55\ (\frac{4.76}{n} - 1)} = \frac{100\ n}{n + 5.52 - 1.16\ n}$$

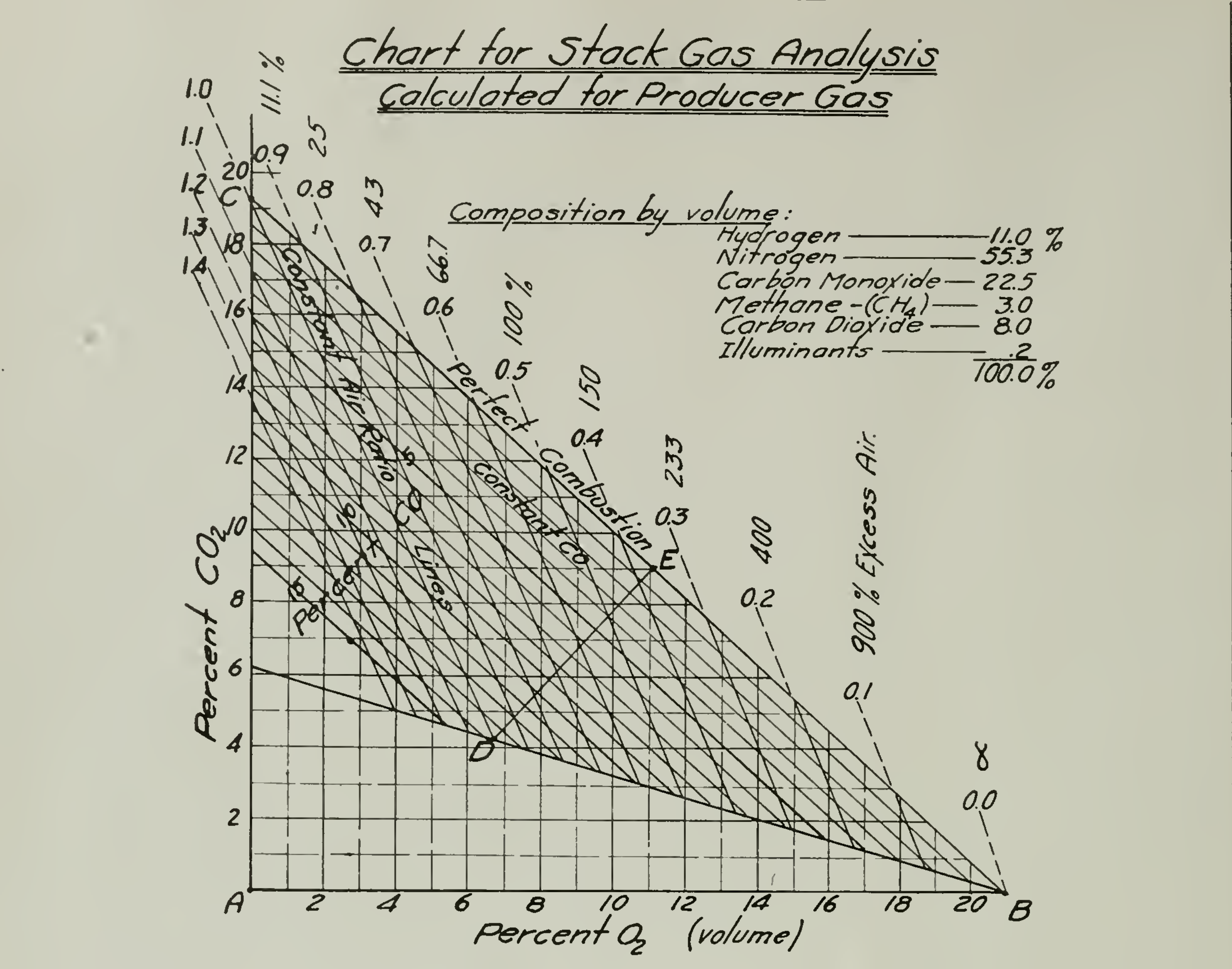


Fig. 5.

$$= \frac{100\ n}{5.52 - .16\ n}$$

$$O_2 \text{ content} = q = \frac{O_{min}\ (\frac{1}{n} - 1) \times 100}{30\ c_1 + O_{min}\ (\frac{4.76}{n} - 1)} =$$

$$\frac{26.55\ (\frac{1 - n}{n}) \times 100}{30 \times .7625 + 25.55\ (\frac{4.76 - n}{n})}$$

$$= \frac{100\ (1 - n)}{.861\ n + (4.76 - n)} = \frac{100\ (1 - n)}{4.76 - .139\ n}$$

From these equations are calculated the CO_2 and oxygen content for various values of n, as shown in Table I.

TABLE I.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$.160\ n =$	.16	.144	.128	.112	.096	.080	.064	.048	.032	.016	0	.176	.192	.208	.224	.240	.256
$(5.52 - .160\ n) =$	5.36	5.376	5.392	5.408	5.424	5.440	5.456	5.472	5.488	5.504	5.52	5.344	5.328	5.312	5.296	5.280	5.264
CO_2 content $= k = \frac{100\ n}{(5.52 - .160\ n)} =$	18.66	16.77	14.87	12.93	11.07	9.20	7.34	5.48	3.64	1.81	0	20.60	22.53	24.45	26.45	28.40	30.40
$.139\ n =$	.139	.1251	.1112	.0973	.0834	.0695	.0556	.0417	.0278	.0139	0	.153	.167	.181	.195	.208	.222
$(4.76 - .139\ n) =$	4.621	4.635	4.649	4.663	4.677	4.691	4.704	4.718	4.732	4.746	4.760	4.607	4.593	4.579	4.565	4.552	4.538
$(1 - n) =$	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	–.1	–.2	–.3	–.4	–.5	–.6
O_2 content $= q = \frac{100\ (1 - n)}{(4.76 - .139\ n)} =$	0	2.16	4.30	6.47	8.55	10.68	12.76	14.83	16.91	18.99	21.00	–2.17	–4.35	–6.55	–8.75	–11.00	–13.23

Each point determined by the values of **k** and of **q** for a given value of n, must be on the straight line CB, which is drawn connecting the point $k_{max} = 18.66$ with point $q_{max} = 21.0$. This is a test of the correctness of the calculations. The line CB is extended to the left, and the points laid off on it for **n** greater than 1 are used for drawing the air factor lines for these values of **n**.

The part of the diagram to the left of line AC consists of construction lines only. The field enclosed in the triangle ACB includes all possible stack gas analyses, provided that all hydrogen has been burned to H_2O—which means most practical cases.

b) Incomplete combustion — points on axis of abscissas AB:

CO content = p =

$$\frac{3000\ c_1}{30\ c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

$$O_{min} = 26.55 \text{ as above. } O'_{min} = 15\ c_1 + 89\ h_1$$

$$= 15 \times .7625 + 89\ (.0495 - \frac{.0653}{8})$$

$$= 15.113 \text{ cu. ft. } O_2 \text{ per pound of coal.}$$

$$p = \frac{3000 \times .7625}{30 \times .7625 + \frac{4.76}{n} \times 26.55 - 15.113}$$

$$p = \frac{100\ n}{5.52 + .339\ n}$$

O_2 content = q =

$$\frac{(\frac{1}{n} O_{min} - O'_{min}) \times 100}{30\ c_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

$$= \frac{(\frac{1}{n} \times 26.55 - 15.113) \times 100}{30 \times .7625 + \frac{4.76}{n} \times 26.55 - 15.113}$$

$$= \frac{(\frac{1}{n} - .570) \times 100}{\frac{4.76}{n} + .291}$$

$$q = \frac{100\ (1.757 - n)}{8.36 + .511\ n}$$

Points obtained from these equations are shown in Table II.

The points for O_2 content are located on the line AB. Through these and their corresponding points for the same air factor **n** on line CB (calculated in **a**), are drawn the straight lines representing constant air factors. Line CD, with n = 1, divides the field of excess air conditions (to the right of CD) from the field of air deficiency conditions (to the left to CD). Constant CO lines are parallel to CB and are equally spaced. Length DE represents 17.05 per cent CO, as shown in Table II for n = 1.

Examples following will show the method of using the chart:

Point I. Stack gas analysis showed $CO_2 = 13.0$ per cent, $O_2 = 6.3$ per cent.
From Fig. 1, CO = 0 (complete combustion), n = .70; $\frac{1}{n} = 1.43$, or 43 per cent excess air.

Point II. $CO_2 = 13.0$ per cent, $O_2 = 1.0$ per cent.
From Fig. 1, CO = 7.2 per cent; n = 1.125; $\frac{1}{n} = .89$, or 11 per cent deficiency of air.

Point III. $CO_2 = 13.0$ per cent, $O_2 = 5.0$ per cent.
From Fig. 1, CO = 1.8 per cent; n = .80; $\frac{1}{n} = 1.25$, or 25 per cent excess air.

In spite of this excess air, combustion is incomplete. This may be caused by imperfect mixture of air with the gases rising from the coal, or by chilling of the gases.

A chart for coal tar, calculated in a similar manner, is shown in Fig. 2.

The only case in which the chart for coal, in Fig. 1, will not give correct results, is that in which there is deficiency of air and the temperature is not high enough to cause complete combustion of the hydrocarbons. For instance, in sheet heating furnaces using bituminous coal on the grate, where it is necessary to have in the furnace a flame containing hydrocarbons, the latter may break up. and produce soot (free carbon), or they may pass out unchanged. In either event, the

TABLE II.

n =	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$\frac{5.52}{n}$ =	5.520	6.130	6.900	7.890	9.200	11.040	13.800	18.400	27.600	55.200		5.015	4.600	4.250	3.945	3.680	3.453
$(.339 + \frac{5.52}{n})$ =	5.859	6.469	7.239	8.229	9.539	11.379	14.139	18.739	27.939	55.539		5.354	4.939	4.589	4.284	4.019	3.792
CO_2 content = p = $\frac{100}{(.339 + 5.52/n)}$ =	17.05	15.47	13.82	12.16	10.49	8.79	7.07	5.33	3.58	1.80	0	18.70	20.27	21.82	23.35	24.87	26.40
.511 n =	.511	.460	.409	.358	.307	.256	.205	.153	.102	.051	0	.562	.614	.665	.716	.766	.818
(8.36 + .511 n) =	8.871	8.820	8.769	8.718	8.667	8.616	8.565	8.513	8.462	8.411	8.36	8.922	8.974	9.025	9.076	9.126	9.178
(1.757 — n) =	.757	.857	.957	1.057	1.157	1.257	1.357	1.457	1.557	1.657	1.757	.657	.557	.457	.357	.257	.157
O_2 content = q = $\frac{100\ (1.757 - n)}{8.36 + .511\ n}$ =	8 54	9.72	10.91	12.11	13.34	14.58	15.82	17.10	18.38	19.70	21.00	7.36	6.21	5.07	3.94	2.82	1.71

flue gas analysis would not check with the chart.

II. Method for Gaseous Fuels. (Fig. 3.)

Let one cubic foot of fuel gas contain h_1 cu. ft. of H_2, p_1 cu. ft. of CO, N_1 cu ft. of Nitrogen, v_1 cu ft. of CH_4, k_1 cu. ft. of CO_2, q_1 cu. ft. of O_2, r_1 cu. ft. of C_2H_4, s_1 cu. ft. of C_2H_2. Let one cu. ft. of dry flue gas contain k per cent CO_2, p per cent CO, q per cent O_2.

(a) Complete combustion, without formation of CO — line CB, Fig. 2.

1) $2\ H_2 + O_2 = 2\ H_2O$; 1 cu. ft. H_2 requires 0.5 cu. ft. O_2. H_2O disappears.

2) $2\ CO + O_2 = 2\ CO_2$; 1 cu. ft. CO requires 0.5 cu. ft. O_2 and produces 1 cu. ft. CO_2.

3) $CH_4 + 2\ O_2 = CO_2 + 2\ H_2O$; 1 cu. ft. CH_4 requires 2 cu. ft. O_2 and produces 1 cu. ft. CO_2.

4) CO_2 passes into the flue gas without change. 1 cu. ft. CO_2 produces 1 cu. ft. CO_2.

5) $C_2H_4 + 3\ O_2 = 2\ CO_2 + 2\ H_2O$; 1 cu. ft. C_2H_4 requires 3 cu. ft. O_2 and produces 2 cu. ft. of CO_2.

6) $2\ C_2H_2 + 5\ O_2 = 4\ CO_2 + 2\ H_2O$; 1 cu. ft. C_2H_2 requires 2½ cu. ft. O_2 and produces 2 cu. ft. CO_2.

Theoretical oxygen volume for 1 cu. ft. of fuel gas $= O_{min} = .5h_1 + .5p_1 + 2.\ v_1 + 3.\ r_1 + 2.5\ s_1 - q_1$.

Actual oxygen volume for 1 cu. ft. of stack gas $=$

$$O_a = \frac{1}{n} O_{min}.$$

Dry stack gas volume from 1 cu. ft. of fuel gas $=$ $[CO_2 = p_1 + v_1 + k_1 + 2\ r_1 + 2\ s_1 = A = k$ per cent of stack gas volume$]$

$+\ [N = N_1 + \frac{79}{21}\frac{1}{n} O_{min}] + [O_2 = \frac{1}{n} O_{min} -$ $O_{min} = q$ per cent of stack gas volume.$]$

Solving for CO_2 content $= k =$

$$\frac{100\ A}{A + N_1 + \frac{79}{21}\frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O_{min}}$$

$$= \frac{100\ A}{A + N_1 + (\frac{4.76}{n} - 1)\ O_{min}}$$

O_2 content $= q =$

$$\frac{100\ O_{min}\ (\frac{1}{n} - 1)}{A + N_1 + O_{min}\ (\frac{4.76}{n} - 1)}$$

As before, different values of n furnish corresponding points on line CB (this time in Fig. 3).

(b) Incomplete combustion without formation of CO_2, but with complete combustion of hydrogen,— points on the straight line BF. All carbon burned to CO.

1) $2\ H_2 + O_2 = 2\ H_2O$; 1 cu. ft. H_2 requires 0.5 cu. ft. O_2; water vapor disappears.

2) CO remains unchanged; 1 cu. ft. CO in fuel produces 1 cu. ft. of CO in the stack gas.

3) $2\ CH_4 + 3\ O_2 = 2\ CO + 4\ H_2O$; 1 cu. ft. CH_4 requires 1.5 cu. ft. O_2 and produces 1 cu. ft. CO.

4) CO_2 remains unchanged; 1 cu. ft. of CO_2 in fuel produces 1 cu. ft. CO_2 in stack gas.

5) $C_2H_4 + 2\ O_2 = 2\ CO + 2\ H_2O$; 1 cu. ft. C_2H_4 requires 2 cu. ft. O_2 and produces 2 cu. ft. CO.

6) $2\ C_2H_2 + 3\ O_2 = 4\ CO + 2\ H_2O$; 1 cu. ft. C_2H_2 requires 1.5 cu. ft. O_2 and produces 1 cu. ft. CO.

From these equations follows the theoretical air volume for 1 cu. ft. of fuel:

$$O'_{min} = .5\ h_1 + 1.5\ v_1 + 2\ r_1 + 1.5\ s_1 - q_1.$$

Actual oxygen volume for 1 cu. ft. of fuel gas with the same air volume as under (a) $= O_a = \frac{1}{n} O_{min}$. Dry stack gas volume resulting from 1 cu. ft. of fuel $=$ $[CO_2 = k_1 = k$ per cent of stack gas volume$] + [CO$ $= p_1 + v_1 + 2\ r_1 + 2\ s_1 = B = p$ per cent of stack gas volume$] + [N = N_1 + \frac{79}{21}\frac{1}{n} O_{min}] + [O_2 = \frac{1}{n}$ $O_{min} - O'_{min} = q$ per cent of stack gas volume$]$.

From this follows:

CO_2 content $= k =$

$$\frac{100\ k_1}{k_1 + B + N_1 + \frac{79}{21}\frac{1}{n} O_{min} + \frac{1}{n} O_{min} - O'_{min}}$$

$$= \frac{100\ k_1}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

CO content $= p =$

$$\frac{100\ B}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

O_2 content $= q =$

$$\frac{(\frac{1}{n} O_{min} - O'_{min}) \times 100}{k_1 + B + N_1 + \frac{4.76}{n} O_{min} - O'_{min}}$$

These equations give points on the straight line BF. The lines of constant air ratios are those joining points on CB with corresponding points on BF, calculated for the same value of **n**.

It is advisable to place the CO divisions on the line DE, which is drawn perpendicular to CB and passes through intersection D of line BF with the air ratio line for **n** = 1.

A numerical example will be given for coke oven gas, of the following composition (percentages by volume):

Hydrogen	H_2	47.6%	h_1
Carbon monoxide	CO	1.9%	p_1
Nitrogen	N	13.4%	N_1
Methane	CH_4	32.3%	v_1
Carbon dioxide	CO_2	1.6%	k_1
Oxygen	O_2	0.5%	q_1
Ethylene	C_2H_4	2.1%	r_1
Hydrogen sulphide	H_2S	0.6%	
		100.0%	

(a) Complete combustion,—calculation for points on line CB.

CO_2 content = k =

$$\frac{100\ A}{A + N_1 + (\frac{4.76}{n} - 1)\ O_{min}}$$

$A = p_1 + v_1 + k_1 + 2\ r_1 + 2\ s_1 = .019 + .323 + .016 + .042 + 0 = .400$

$O_{min} = .5\ h_1 + .5\ p_1 + 2\ v_1 + 3\ r_1 + 2.5\ s_1 - q_1$
$= .5 \times .476 + .5 \times .019 + 2 \times .323 + 3 \times .021 + 2.5 \times 0 - .005$
$= .951$ cu. ft. oxygen per cu. ft| of fuel. $N_1 = .134$

$$k = \frac{100 \times .400}{.400 + .134 + (\frac{4.76}{n} - 1) \times .951}$$

$$= \frac{100}{1 + .335 + (\frac{4.76}{n} - 1) \times 2.375}$$

$$k = \frac{100}{1.335 + \frac{11.305}{n} - 2.375} = \frac{100\ n}{11.305 - 1.04\ n}$$

Oxygen content = q =

$$\frac{100\ O_{min}\ (\frac{1}{n} - 1)}{A + N_1 \times O_{min}\ (\frac{4.76}{n} - 1)}$$

$$= \frac{100 \times .951\ (\frac{n - 1}{n})}{.400 + .134 + 951\ (\frac{4.76 - n}{n})}$$

$$= \frac{100\ (\frac{n - 1}{n})}{.562\ \frac{n}{n} + (\frac{4.76 - n}{n})} = \frac{100\ (n - 1)}{4.76 - .438\ n}$$

From these equations are calculated the CO_2 and oxygen content for various values of **n**, as shown in table III.

TABLE III.

n =	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
1.04 n =	1.040	.936	.832	.728	.624	.520	.416	.312	.208	.104	0	1.144	1.248	1.352	1.456	1.560	1.662
(11.305 — 1.04 n) =	10.265	10.369	10.467	10.577	10.681	10.785	10.889	10.993	11.097	11.201	11.305	10.161	10.057	9.943	9.849	9.745	9.643
CO_2 content = k = $\frac{100\ n}{(11.305 - 1.04\ n)}$ =	9.74	8.69	7.65	6.61	5.62	4.64	3.67	2.75	1.80	.89	0	10.83	11.94	13.09	14.20	15.40	16.60
.438 n =	.438	.394	.350	.306	.263	.219	.175	.131	.088	.044	0	.482	.526	.570	.614	.657	.701
(4.76 — .438 n) =	4.322	4.366	4.410	4.454	4.497	4.541	4.585	4.629	4.672	4.716	4.760	4.278	4.234	4.190	4.146	4.103	4.059
(n — 1) =	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	–.1	–.2	–.3	–.4	–.5	–.6
O_2 content = q = $\frac{100\ (n - 1)}{(4.76 - .438\ n)}$ =	0	2.29	4.53	6.73	8.90	11.02	13.10	15.12	17.13	19.10	21.0	–2.34	–4.72	–7.16	–9.65	–12.19	–14.77

As before, each point determined by the values of **k** and **q** corresponding to a given value of **n**, must lie on the straight line CB ,in Fig. 3, drawn connecting the point $k_{max} = 9.74$ with point $q_{max} = 21.0$. This is a test of the correctness of the calculations. As before, the line CB is extended to the left of C, to furnish air ratio lines for **n** greater than 1. All possible stack gas analyses for this fuel are represented by the field enclosed in the triangle BCF, provided no hydrogen remains unburned.

(b) Incomplete combustion,—Points on line BF.

CO content = p =

$$\frac{100\ B}{k_1 + B + N_1 + \frac{4.76}{n}\ O_{min} - O'_{min}}$$

$B = p_1 + v_1 + 2\ r_1 + 2\ s_1 = .019 + .323 + 2 \times .021 + 2 \times 0 = .384$

$k_1 = .016 \quad N_1 = .134 \quad O_{min} = .951$ (same as "a")

$O'_{min} = .5\ h_1 + 1.5\ v_1 + 2\ r_1 - 1.5\ s_1 - q_1 = .5 \times .476 + 1.5 \times .323 + 2 \times .021 - 1.5 \times 0 - .005 = .759$ cu. ft. O_2 per cu. ft. fuel gas.

CO content = p =

$$\frac{100 \times .384}{.016 + .384 + .134 + \frac{4.76}{n} \times .951 - .759}$$

$$= \frac{100 \times .384}{\frac{4.76 \times .951}{n} - .225}$$

$$= \frac{100\ n}{11.80 - .585\ n}$$

O_2 content = q =

$$\frac{(\frac{1}{n}\ O_{min} - O'_{min}) \times 100}{k_1 + B + N_1 + \frac{4.76}{n}\ O_{min} - O'_{min}}$$

$$= \frac{(\frac{.951 - .759\ n}{n}) \times 100}{\frac{4.76 \times .951}{n} - .225}$$

$$= \frac{100\ (1 - .798\ n)}{(4.76 - .237\ n)}$$

CO_2 content = k =

$$\frac{100\ k_1}{k_1 + B + N_1 + \frac{4.76}{n}\ O_{min} - O'_{min}}$$

$$= \frac{100 \times .016}{\dfrac{4.76 \times .951}{n} - .255}$$

$$= \frac{100\ n}{282.5 - 14.06\ n}$$

and their corresponding points on CB for equal values of **n**, are drawn the straight lines representing constant air ratios. The CO divisions are marked off on line DE, drawn perpendicular to CB, and passing through that O_2 point of line BF for which $\mathbf{n} = 1$. Length DE then represents 8.90 per cent CO, as shown in Table IV for the value $\mathbf{n} = 1$.

TABLE IV.

$n =$	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0	1.1	1.2	1.3	1.4	1.5	1.6
$.585\ n =$	.585	.526	.468	.410	.351	.293	.234	.176	.117	.059	0	.644	.702	.760	.819	.878	.936
$(11.80 - .585\ n) =$	11.215	11.274	11.332	11.390	11.449	11.507	11.566	11.624	11.683	11.741	11.800	11.156	11.098	11.040	10.981	10.922	10.864
CO content $= p = \dfrac{100\ n}{11.80 - .585\ n} =$	8.90	7.99	7.06	6.15	5.21	4.31	3.46	2.58	1.71	.85	0	9.85	10.82	11.77	12.76	13.73	14.72
$14.06\ n =$	14.06	12.65	11.25	9.83	8.43	7.02	5.62	4.22	2.81	1.41	0	15.47	16.88	18.28	19.69	21.08	22.48
$(282.5 - 14.06\ n) =$	268.44	269.85	271.25	272.67	274.07	275.48	276.88	278.28	279.69	281.09	282.50	267.03	265.62	264.22	262.81	261.42	260.02
CO_2 content $= k = \dfrac{100\ n}{282.5 - 14.06\ n} =$	.37	.33	.30	.26	.22	.18	.15	.11	.07	.03	0	.41	.45	.49	.53	.58	.62
$.237\ n =$	.237	.213	.190	.166	.142	.118	.095	.071	.047	.024	0	.261	.284	.308	.332	.356	.380
$(4.76 - .237\ n) =$	4.523	4.547	4.570	4.594	4.618	4.642	4.665	4.689	4.713	4.736	4.760	4.499	4.476	4.452	4.428	4.404	4.380
$.798\ n =$	.798	.718	.639	.559	.479	.399	.319	.240	.160	.080	0	.878	.957	1.039	1.119	1.198	1.278
$(1 - .798\ n) =$	.202	.282	.361	.441	.521	.601	.681	.760	.840	.920	1.000	.122	.043	−.039	−.119	−.198	−.278
O_2 content $= q = \dfrac{100\ (1 - .798\ n)}{4.76 - .237\ n} =$	4.46	6.20	7.90	9.60	11.28	12.97	14.61	16.22	17.82	19.47	21.0	2.71	.96	−.89	−2.09	−4.50	−6.35

From these equations are calculated the CO, oxygen, and CO_2 content for various values of **n**, as shown in Table IV.

The points on the straight line BF, Fig. 3, are located by means of the O_2 and CO_2 contents shown in Table IV, for given values of **n**. Through these points

The lines of constant CO are drawn parallel to CB and are evenly spaced. Lines of constant air ratio, though straight, are not parallel to each other, nor are their intersection points on CB evenly spaced.

Charts for other gaseous fuels have been calculated in a similar manner, and are shown in Figures 4 and 5.

Superpower Plan Would Over-come Large Waste

Recent investigations by the United States Geological Survey, Department of the Interior, in what is known as the superpower zone—the dense industrial region between Washington and Boston — show a waste of coal used in the production of power by the industrial establishments in this zone in the year 1919 to the amount of 13,502,100 tons. In other words, the energy developed by these establishments by the burning of 19,125,900 tons of coal could have been developed in large central power plants by the burning of 5,623,800 tons. This was a waste through inefficient independent power production of 71 per cent in coal consumption.

The industry using the largest amount of coal in the region is anthracite mining, and in this industry a coal saving of more than 75 per cent could be made if the mines were supplied from an efficient central electric power system. Many industries, it is stated, could save coal by the use of waste-heat boilers. Probably the greatest saving by this means could be made in the cement industry. It is estimated that if waste-heat boilers had been in use in 1919 in all the cement plants in the superpower zone, 540,000 tons of coal would have been saved in that single industry.

There are many blast furnaces in the superpower zone which are isolated from any steel plants or rolling mills, and approximately half their gases are wasted. These wasted gases would produce sufficient heat for boilers to generate 500,000,000 kilowatt-hours a year.

In certain plants the low-pressure steam requirements greatly exceed the power requirements, and there is no reason why such plants should not generate by-product power and sell it to the electrical distributing companies.

Men Who Helped to Make the Steel Industry

JOSEPH GREEN BUTLER, JR.

Sketch of Career of Joseph G. Butler, Jr.

JOSEPH GREEN BUTLER, JR., was born at Temperance Furnace, Mercer County, Pa., on December 21, 1840. His father was Joseph Green Butler, and his mother, Temperance Orwig Butler, the former having been an ironmaster and the latter descended from one of the oldest families in Berks County, Pa., although born at Salem, Ohio, whither her parents had removed with the earliest settlers of that state.

The lineage of the Butler family is worthy of being recorded here, not only because it can be traced back for almost a thousand years, but because of the extremely prominent part members of the family played in the American Revolution and their activity in the earlier years of the Republic. The family became noted in Ireland under the reign of Henry II, ruling the Palatinate of Ormond, now County of Tipperary. It had a large part in the political and religious history of the country until the early part of the Eighteenth Century, when political troubles led to the imigration to America of Thomas and William Butler. These two brothers, together with five of their sons, held commissions in the American Army during the Revolution, acquitting themselves in such a way as to lead General Washington, at a banquet held after the surrender of Lord Cornwallis at Yorktown, to offer a toast to their loyalty and courage, using the following words: "To the Butlers and their five sons." This toast was responded to by General Lafayette with the observation that, when he wanted anything well done, he had a Butler do it. During the troublesome times following the close of the War for Independence, these Butlers served the country faithfully in the Indian wars of the period, as well as other capacities. Gen. Richard Butler, son of Thomas and Ann Dalyrimple Butler, was killed at the battle of the Miamis, in Ohio, and his cousin, Col. Edward Butler, son of William Butler, was wounded in the same struggle with the savages.

The personal acquaintance between General Washington and Col. Thomas Butler, original ancestor in America of the subject of this sketch, doubtless led to Col. Butler becoming interested in the manufacture of iron, as General Washington and his brother had erected a small blast furnace in Virginia shortly after the close of the Revolution. He was later engaged as a charcoal contractor, furnishing fuel for a number of blast furnaces in Pennsylvania, being connected in this way with such famous pioneer iron firms as Spang, Lyon & Shorb, the Shoenbergers, and others. He followed this occupation to the end of his life, and his six sons were also engaged in it. Col. Thomas Butler died at the home of his son, David, near Roaring Springs, Pa., in 1832, at the age of 92 years.

Of the six sons above referred to, the last was Joseph, born January 7, 1779, at Milesburg, Center County, Pa., where his father was connected with the first blast furnace built in Central Pennsylvania. This stack was erected by Col. Samuel Miles and Col. Patton, both officers in the Revolutionary Army. Joseph Butler married Esther Green, whose mother was a sister of Col. Samuel Miles. The Miles family was of Welsh descent, having come to America with, or shortly after William Penn, and having been prominent in the affairs of Philadelphia, Col. Samuel Miles being Mayor of the City at one time. To this union were born two sons and three daughters, of whom Joseph Green Butler, father of Joseph Green Butler, Jr. was the youngest. After the death of Esther Green Butler, Joseph Butler married again, his second wife being Rachel Gould Parker, by whom he had a number of children. The children of the first marriage were reared by the mother's family, the two groups being thus separated and, scattering to different parts of the country, were unknown to one another for many years. Joseph Butler was an ironmaster of considerable note. With his father and his brother, James, he conducted a forge at Bellefonte, producing blooms of such excellence that the name under which they were sold, "Juniata Blooms" was preserved and used long after the original forge and its owners had passed away. He served in the War of 1812, and was prominent in the affairs of his community, having been selected to keep the "inn or house of public entertainment" at Bellefonte in 1816. He was also elected sheriff of Center County in 1821.

Joseph Green Butler, son of Joseph Butler and Esther Green, was, like his father before him and his son, Joseph Green Butler, Jr., an ironmaster of reputation. For some years he followed the iron business in Central Pennsylvania. As the ore and fuel supplies in that Section became exhausted, he came westward and was soon recognized as an expert in Western Pennsylvania and Eastern Ohio, then beginning to be known as iron producing territory. After spending some time as manager for different furnace companies, he became associated with some eastern people in the operation of a blast furnace at New Wilmington, Pa., succeeding in the management of this enterprise William McKinley, father of President William McKinley. About 1838 he erected near Hadley, Mercer County, Pa., a small blast furnace, which he named "Temperance Furnace," after his wife, Temperance Orwig Butler. It was within a few feet of this stack that the subject of this sketch was born. Later Joseph Green Butler was Manager of furnaces for the famous old firm of James Ward & Company, which built the first bar mill in Ohio, at Niles. Still later he was in charge of the mercantile department of that firm. He was married to Temperance Orwig, and they had seven sons and three daughters. He died at Cleveland in 1895, and his wife survived him four years. Joseph Green Butler was a man of unusual attainments and character, enjoying the respect and esteem of a wide circle of friends.

Joseph Green Butler, Jr., subject of this sketch, was the third son of Joseph Green Butler and Temperance Orwig Butler. He was about one year old when his father removed from Temperance Furnace to Niles, Ohio, in order to take charge of the mercantile department of James Ward & Company. At Niles, therefore, he spent his entire boyhood, with the exception of one year, 1853, during which his father managed a blast furnace at New Wilmington. At Niles, he attended the village school, in company with William McKinley, afterward President of the United States, as well as of others who later became widely known. During his school years he seems to have been an apt pupil, but he was at the same time one of the most vigorous and resourceful of the group above referred to, and, in spite of the meager opportunities, acquired the foundation of a thorough education. He inherited from a long line of ancestors the courage, energy and ability which have enabled him to become one of the most widely known iron and steel manufacturers in the United States, and it is probable that his remarkable accomplishments in the field of industry, finance, art and letters may be credited to an indomitable spirit of achievement, derived from the mixture of Irish, Scotch and Welsh blood in his veins. Whatever may have been the source of this spirit, he has established a record of public .and private achievement not often equalled, and his life and work form a source of inspiration for all who seek in the larger sense to make the world better for having lived in it.

Mr. Butler was about fifteen years of age, when, in 1855, he entered the store conducted by his father tor James Ward & Company in the capacity of a clerk. In this position he made himself particularly useful by acquiring the Welsh language from the miners who patronized the establishment as well as helping to keep the accounts. One day Mr. Ward came into the store and announced that he wanted some one to fill the position of shipping clerk in the iron works, which was temporarily vacant. He selected Mr. Butler for the task, and this was so well performed that the young man was given the position permanently, and rapidly advanced until he became active in the management of the works. In 1858, his father was elected Sheriff of Trumbull County, removing, with the remainder of the family to Warren, the county seat. Mr. Butler, however, chose to remain with Ward & Company, and was taken into the Ward family, in which he made his home during the time he was with the firm, being later made Financial Manager of the Company.

In 1863, he became District Representative of Hale & Ayer, a Chicago firm, with whom he remained until 1866, resigning to become Manager of the Girard Iron Company, in which enterprise he was associated with David Tod, the famous "War Governor of Ohio," William Ward and William Richards. They built the first blast furnace in the Mahoning Valley, equipped with a closed top, and conducted the business under the name of the Girard Iron Company for twelve years, when he sold his interests to become Manager of the Brier Hill Iron Company. This was one of the most widely known iron-making establishments of its time, operating blast furnaces and later mining coal on a large scale. It continued successful operations for many years, being finally re-organized in 1912 under the name of the Brier Hill Steel Company, of which Mr. Butler, its original Manager is now Vice-President.

In the long interval between 1868 and 1912, Mr. Butler was connected with many other enterprises, and since that time his activities have been even still further extended. He was one of the organizers of the Ohio Steel Company, the first concern to make steel in the Mahoning Valley, being Vice President of the Company for a number of years. At this time he is a Director of The American Iron & Steel Institute, President of the Portage Silica Company, Vice-President of The Brier Hill Steel Company, Chairman of the Board of Directors of The Bessemer Limestone & Cement Company, Director of The Youngstown Sheet & Tube Company, The Pennsylvania & Lake Erie Dock Company, The Cleveland & Mahoning Valley Railway Company, Pittsburgh, Youngstown & Ashtabula Railroad Company, New York, Pennsylvania & Ohio Light & Power Company, Youngstown & Suburban Railway, The Youngstown Municipal Railway Company, The Commercial National Bank, and numerous other less important enterprises. His business interests include almost every successful industrial enterprise in the Mahoning Valley, and he is interested in many similar undertakings elsewhere. His activities in the iron and steel business are especially notable, and his acquaintance among the leaders in this industry in all parts of the world is probably not exceeded by that of any living man, extending backward more than a generation and including all of those who had a large part in the modern development of steel manufacture in this country and abroad.

In spite of these multiplied interests, Mr. Butler has devoted a great deal of time to humanitarian work, as well as art and literature. Nor has he neglected politics, although he has never been a candidate for political office except when it offered no rewards except honors and an opportunity to serve his country. He has been a delegate to three Republican National Conventions, the last being that at which Warren G. Harding was nominated tor President, Mr. Butler having been among the leaders of the long contest necessary to bring about that result. He has appeared before the Committee of Ways and Means and the Senate Finance Committee during the framing of almost every tariff bill since 1870, and has numbered among his personal friends, every Republican President since and including Grant. He took part in every Presidential election since and including that of Abraham Lincoln, and has been a consistent Republican during the whole period.

For many years Mr. Butler has been interested in art, and his collection of pictures is among the most notable in the United States, outside of New York. In 1918-19 Mr. Butler erected in the City of Youngstown one of the handsomest art galleries in the country, presenting it to the city, with an endowment fund to provide for its maintenance perpetually. This beautiful structure is devoted to the encouragement of American artists and now contains a large collection of choice paintings by American artists, all of which were donated by the builder. Connected with it is a free school of art instruction under able management.

Mr. Butler has gathered one of the finest private libraries in America. In addition he has written a number of widely known works, among these being "Life of McKinley," "First Trip Across the Continent," "First Trip Abroad," "Presidents I have Seen and Known," "A Journey Through France in War Time," "Fifty Years of Iron and Steel," and "History of Youngstown and the Mahoning Valley." Of these, the last named is in four volumes, "Fifty Years of Iron and Steel" is now in its Fifth Edition. All of these works were published privately.

Mr. Butler was, as has been noted, a boyhood friend and schoolmate of President William McKinley, and their close friendship endured through the whole of the martyred President's life. Many years ago he conceived the idea of erecting a memorial to mark the place of McKinley's birth, and, after years of labor, brought this idea to fruition in what is perhaps the most beautiful and elaborate structure of this kind on the American continent. It is located at Niles, and is daily visited by people from all parts of the country and even many persons from abroad. This splendid memorial is of Georgia marble, with a heroic statue of McKinley as its crowning feature. It was designed by McKim, Mead & White and planned as an educational institution, containing art and memorabilia calculated to inspire study of history and love of country. Among these are a library, auditorium, museum of historical relics and many busts of the most famous men in the history of American politics, statesmanship and industry. Its cost, about half a million dollars, was defrayed largely by contributions from people in all walks of life, but the credit for its erection belongs entirely to Mr. Butler, who is President of the Organization erecting it, The National McKinley Birthplace Memorial Association.

In addition to the accomplishments here merely outlined along the line of industry, politics, art and literature, Mr. Butler has always been intensely interested in humanitarian work and has been connected with every movement of this kind in the Mahoning Valley for many years. Anything that offered an opportunity to inspire patriotism, instill pride in and affection for country and community, was eagerly embraced by him and given energetic and effective support. He was originator and one of the incorporators and is now a member of the Board of Governors of Sulgrave Institution, Sulgrave, England, through which the original home of the Washingtons has been preserved. He served as a member of the American Commission which visited France during the World War as guests of the French Government, and he has been at the head of community efforts, such as Red Cross, Council of National Defense, and all others designed to weld together patriotic and humanitarian sentiment. For seven years Mr. Butler served as President of the Youngstown Chamber of Commerce. He was at the same time President of the Youngstown Humane Society for five years. He has been Vice President General of the Sons of the American Revolution and President of The Mahoning Valley Historical Society and the Mahoning Institute of Art for many years. He is President of the American Pig Iron Association, and was President of the Organization which preceded it in the preparation of statistics concerning this great industry in America, the Bessemer Pig Iron Association.

Mr. Butler is a member of the following Clubs: Duquesne, Pittsburgh; Union, Cleveland; National Arts, Salmagundi, Republican, Grolier, India House and Friars, and the Ohio Society of New York.

He was married on January 10, 1866, to Harriet Voorhess Ingersoll, of an old and well known New Haven, Conn., family, whose death took place on April 27, 1921. Their children included, Blanche, wife of Edward L. Ford, of Youngstown (now deceased); Henry A., a well known business man of Youngstown, and Grace, wife of Arthur McGraw, of Detroit.

From the facts disclosed by the above simple sketch of his activities it is natural that Joseph Green Butler, Jr., should be the most widely known and most beloved citizen of the Mahoning Valley. The esteem and affection in which he is held have been repeatedly expressed publicly by his fellow citizens in the form of days specially set aside in his honor, as well as busts which have been unveiled—one at The Butler Art Institute in Youngstown and another at the McKinley Memorial, in Niles, honors never bestowed on any other citizen of this locality. No other man has rendered such energetic and unselfish service to his country and his community, and he stands out among the historic figures of which northeastern Ohio has produced so large a number.

STEVENS INSTITUTE CELEBRATES ITS 50TH ANNIVERSARY.

Stevens Institute alumni and their friends joined in a 50th anniversary celebration at a notable dinner at Hotel Astor, New York, Thursday evening, Dec. 15. Among the 400 in attendance were a number of engineers who have won national distinction. At each guest's place was a brochure, well illustrated, recounting the 50 years of progress and service in the life of the Hoboken institution founded by Edwin A. Stevens and fostered by the members of his family. Stevens has had but two presidents, Henry Morton serving until 1902 and Alexander C. Humphreys immediately following him. The story of 50 years tells of the gifts made to Stevens in more recent years, including $125,000 from Andrew Carnegie and alumni subscriptions of $507,000.

A noteworthy feature of the dinner was the presence of the entire class of 1877. The 10 men who graduated in that year were applauded roundly as they answered to the call of the roll. They are named below:

A. G. Brinckerhoff, secretary Nash Engineering Co., South Norwalk, Conn.
M. I. Coster, vice-president Westinghouse Electric International Co., New York.
W. E. Geyer, Boonton, N. J.
F. E. Idell, mechanical engineer, 50 Church Street, New York.
L. H. Nash, president Nash Engineering Co., South Norwalk, Conn.
J. B. Pierce, Mercer County, Pa.
J. Rapelje, Hopewell Junction, N. Y.
E. P. Roberts, special consultant and manager Engineering Society of Akron, Akron, Ohio.
E. A. Uehling, president Uehling Instrument Co., Passaic, N. J.
F. VanWinkle, consulting engineer and associate editor "Power," New York.

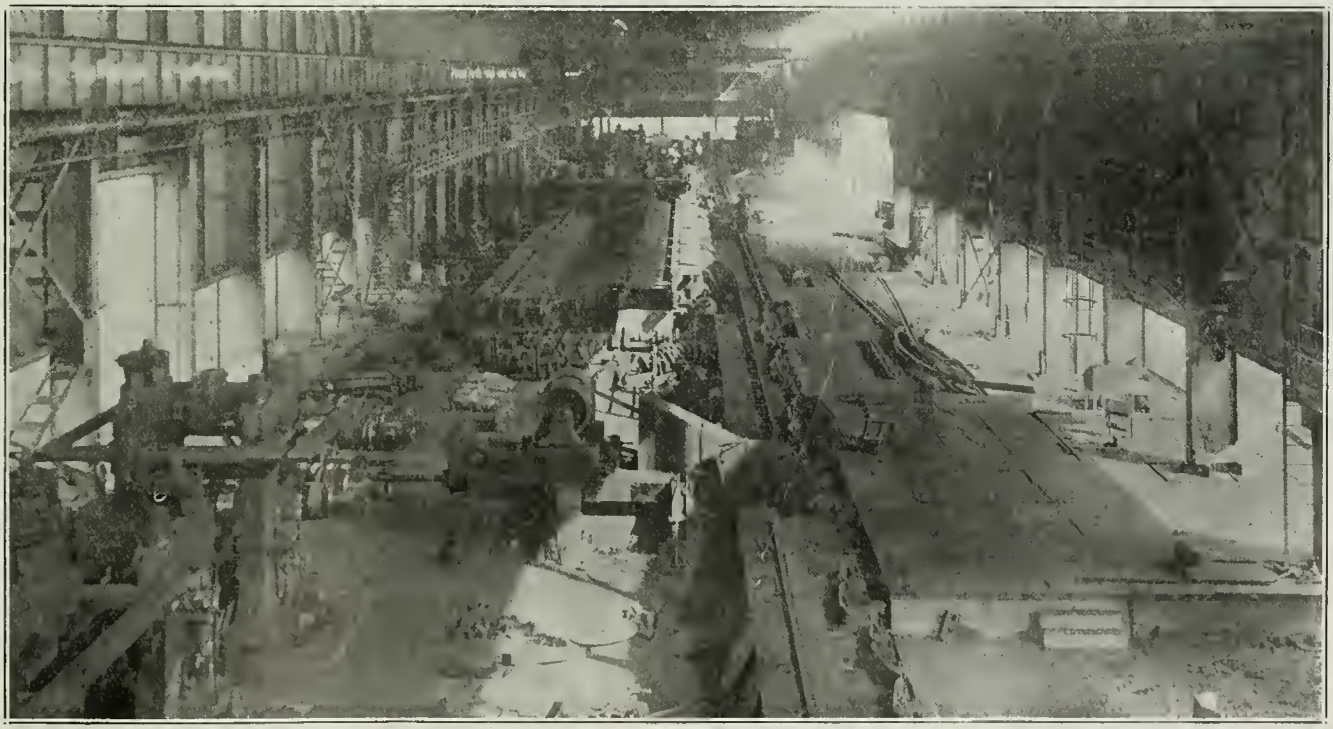
President Humphreys, in an address emphasizing some of the things for which Stevens Institute stands, challenged a statement made at a recent joint conference of the American Society of Mechanical Engineers and the American Society for the Promotion of Engineering Education. One of the speakers at that conference, a university professor, stated that colleges today are aiming at "quantity production" rather than quality of product. This speaker quoted the secretary of the second named society, who is dean of the engineering school of a university, to the effect that "there is no first-class engineering school in America." President Humphreys suggested that the pessimistic opinions of these professors may be attributable in part to the observed results of faulty teaching. To the charge of quantity production the speaker held that Stevens Institute is well justified in pleading not guilty. While there are no perfect institutions, "when we speak of 'first class,' that is relative, and so speaking I disagree with these men and claim there are a number of first class engineering schools in America, of which Stevens is one.

Rolling Mill Department

Electric Drives For Wire Mills

American Rolling Mills for France.

The Mansfield Sheet and Tin Plate Company's
New Steel Unit
By CARL W. PIERCE



Electric Drives For Wire Mills

A General Description of the Modern Electric Drives Recently Installed in the Alabama City Works of the Gulf States Steel Co.

THE steel frame building which houses the wire-drawing benches is 240 feet wide, consisting of four 60-foot bays, and in length that portion devoted to wire-drawing is 340 feet, or 17 20-foot bays. Thus the floor area in this department is 81,600 square feet, all of which is laid with wood blocks. The roof is divided into alternately high and low sections, nearly flat, each 20 feet wide, extending across the full width of the building, 240 feet. The vertical space of 10 to 15 feet between the high and low sections of roof is walled entirely with glass, thus giving very good natural lighting over the entire floor space.

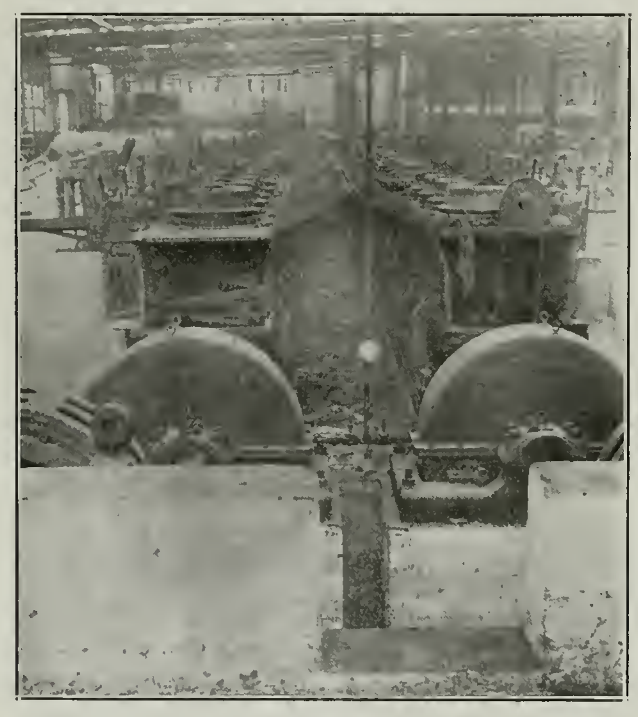


Fig. 1.

Wire Drawing Frames.

There are six wire-drawing frames or benches, each about 175 feet long, running parallel with each other and in the direction of the length of the building; these, together with their drives, extend over about 10 20-foot bays, or 200 feet in the length of the building. As measured across the width of the building, the benches are separated by a distance of from 42 to 44 feet from center to center. The drawing benches were furnished by Humphrey & Sons, Joliet, Ill. Four of these (known as 1, 2, 3 and 4), each driven by a 230-volt d.c. motor, have been in service since the year 1910; the other two (Nos. 5 and 6), each of which is driven by 2,200-volt, 3-phase induction motor, were installed new and started up in August, 1920. Each one of the six benches carries 40 vertical wire-drawing drums or "blocks," and, at intervals, called "pointers," used for tapering the end of the wire to a point so that it may be inserted by hand in the die hole. The old benches (1, 2, 3 and 4) are each provided with seven pointers, and the new benches (Nos. 5 and 6), each have 13 pointers. On the right in Fig. 1 is shown the chain drive to one of the pointers; this is on the end of bench No. 5.

As this picture shows, these two benches (Nos. 4 and 5) are installed close together, back to back, so that the work done on a given bench is all from one side. On the other hand, benches 1, 2, 3 and 4, which have a floor space between them of about 40 feet for location of the reels and for trucking, are built so that about half of the blocks draw from the right and the other half from the left side of the bench.

Old Bench Blocks.

The first block at the motor end of each of these benches is known as the "bull" block and runs at a speed of about 36 rpm., drawing the wire at a speed of about 250 feet per minute; this block is used to draw the heavy rolled rod as it comes from the rod mill after having been annealed and otherwise treated. There are located at intervals throughout the length of each of these benches 13 "ripping" blocks, which run at a speed of about 48 rpm., drawing the wire at a speed of about 330 feet per minute; these blocks are located next to the pointers.

The remaining 26 blocks on each of these benches are "finishing" blocks and run at about 72 rpm., drawing the wire at a speed of about 500 feet per minute.

Bevel Gearing.

A 53-tooth bevel, or miter, gear at lower end of vertical bull block shaft engages a 26-tooth split bevel gear on the line shaft; this latter gear is split in halves to facilitate the work of installing a new gear in event this should become necessary. This gives about a 2 to 1 gear reduction from line shaft to block. A 45-tooth bevel gear on the line shaft, giving a speed reduction of 1½ to 1 from line shaft to block.

A 40-tooth bevel gear on the vertical finishing block shaft engages a 40-tooth split gear on the line shaft; thus the finishing block runs at line shaft speed, 72 rpm.

New Bench Blocks.

Benches Nos. 5 and 6 each have 13 ripping blocks which run at 48 rpm.; these are each located next to a pointer. The remaining 27 finishing blocks on each of these two benches run at a speed of 72 rpm. The speeds at which the wire is drawn on these benches is the same as those on the four old benches, viz., 330 ft. per minute for the ripping blocks and 500 ft. per minute for the finishing blocks.

Gearing.

The bevel gear on the ripping block shaft has 45 teeth and the one with which it engages on the line shaft has 30-teeth, or a reduction in speed of 1½ to 1 from line shaft to block.

The bevel gear on the finishing block shaft and that with which it meshes, on the line shaft, each have 40 teeth; thus the finishing block runs at line shaft speed.

The 40 vertical shafts on each bench revolve at all times when the line shaft is running; and in each case the vertical shaft drives the block through a friction clutch which permits the block to be stopped or started instantly.

To the block there is attached a chain, on the end of which is fastened a pair of grip jaws which are adjusted to take hold of the end of the wire after it has been threaded through the die hole. The clutch is then let in gradually by lifting the foot, after the manner of the left pedal of an automobile; this causes the block to revolve at the same speed as the vertical shaft which carries it.

Fig. 2.

Friction Clutch.

Fig. 2 shows details of the clutch. It also shows the maple friction blocks carried by a "spider" similar in form to a dished wheel, the dish of which may be varied somewhat. When the weight of the friction drum, together with that of the wire drawing block, is lowered on the wood friction blocks there is a tendency to force the "dish" out of the "wheel," causing expansion at the "rim" (friction surface); this force is sufficient to cause the friction to take hold. In other words the toggle action of the "spokes" forces the wood blocks against the friction surface on the inside of the drum (shown at the left in Fig. 2) with sufficient pressure to produce the necessary driving friction. The friction drum carries two pawls which engage the teeth on the inside of the wire drawing block; thus the vertical driving shaft can only produce rotation of the block in one direction.

Mechanical Safety Device.

Fig. 3 shows a bail or yoke shaped lever extending around the die bracket through which the wire is drawn; this bail shaped lever operates an air valve which turns air into or out of two single acting vertical air cylinders placed on opposite sides of the bench.

A forward push on the bail turns air into the two cylinders, producing an upward movement of their plungers and lifting the weight of the friction drum and block off the rotating toggle friction wheel, thus disengaging the clutch and stopping the wire drawing operation instantly, since the inertia of the moving parts above the friction is not sufficient to draw the wire through the die to any appreciable extent.

This is a very quick acting safety device. In event an operator should accidentally become entangled in the wire as it is being drawn through the die, on the instant his body or any part of it bringing slight pressure against the bail the clutch is instantly disengaged, affecting a very sudden stop of rotation of the block.

However, the performance of this safety device depends entirely upon maintenance of air pressure in the line and in event of failure the block must be stopped either by pressure on the foot lever (shown in the extreme lower position in Fig. 3) or by stopping the driving motor at the end of the line shaft which drives the 40 blocks of one bench. Stoppage of the motor in every case is affected by pushing a button; just how this is accomplished will be shown later.

Drives.

For the drives of benches Nos. 1, 2, 3 and 4 we have identical motors designated by our numbers 506, 507, 508 and 509 respectively.

These motors were furnished by Crocker-Wheeler Company. They are size 336-D, 300-hp., 230-volts d.c. shount wound, 12 pole, 72 rpm. machines and each is direct control to one of the bench line shafts by a flange coupling.

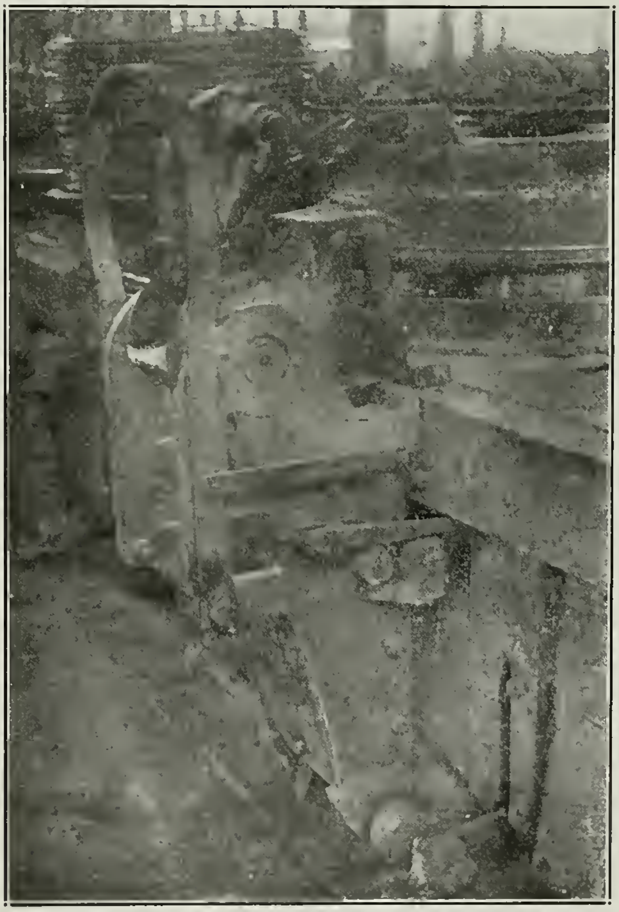


Fig. 3.

One half of this coupling has a 12-in. diameter bore for the armature shaft and the other half is bored 5-5/16 inches to fit the line shaft, which extends throughout the length of the bench, about 175 feet. Fig. 4 shows motor No. 508 which drives No. 3 drawing bench.

Starter.

This pictures gives a good view of the manually operated starting panel used with this motor; starters similar to this are also used in connection with the motors driving benches Nos. 2 and 4.

At bottom of the panel is shown 10 knife switches which must be closed by hand, one at a time, in proper sequence, to cut out the successive resistance steps used in starting the motor. At the top of the panel is shown the two line circuit breakers, one or both of which may be opened for stopping the motor. Between the circuit breakers and above the ammeter is shown a relay, the plunger of which is normally held *up* against gravity, thus bridging across two contact posts through which energy is supplied to the low voltage coil of one of the circuit breakers. The other circuit breaker is equipped with a shunt trip coil which is energized through a pair of contact posts which are short circuited by the relay when the plunger is *down*.

Fig. 4.

Stop Button.

Located on each of the 10 columns at 20-foot intervals near the bench are push buttons, any one of which when pushed will open the circuit through the relay coil, permitting the plunger to drop, thus effecting the operation of the low voltage trip on one breaker and the shunt trip on the other, as above explained. Of course, opening of either circuit breaker will, ordinarily, stop the motor. The several stop buttons are for use in event a man should get caught in the wire and be drawn in by it.

However, due to the characteristic toggle lever construction which is employed for mechanically holding the circuit breaker closed, there is always a chance that the breaker may fail to open in response to the touch of a button.

Starter for No. 1 Bench Motor.

In connection with the motor driving No. 1 bench, there is a magnetic switch starter which was assembled from factory made units; this starting panel carries four line contactors, two on each side of the line; two overload relays; a knife switch for the shunt field and control wiring; and one ammeter.

Since the line contactors are held closed by a circuit which may be interrupted by any one of the ten push buttons on the columns it seems impossible that they could fail to open at the touch of a button.

This starter has never failed to stop the motor instantly at the touch of a button and will also automatically handle the accelerating switches in proper sequence every time.

Failure in the performance of this latter has often resulted in burnt spots on the commutators of the manually started motors. Sometimes in starting up with the old knife switch starters, the motor inspector will inadvertently close the circuit breaker without having previously opened all the knife switches; this usually produces the burnt patches on the commutator as above noted.

Drives of Benches Nos. 5 and 6 Motors.

Each of these benches is driven by a type M T, frame 412, 400-hp., 450 rpm., 2,200-volt, 3-phase, 60-cycle, form B, slip ring induction motor, furnished by General Electric Company.

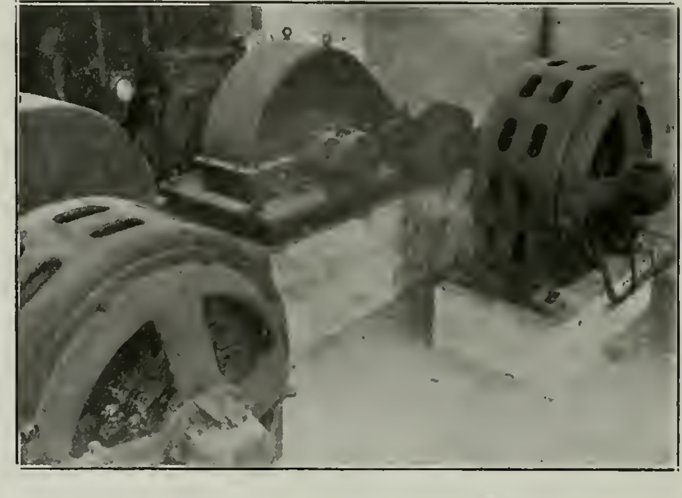


Fig. 5.

Gearing.

The drive is through a Fawcus Machine Company's reducing gear unit, giving a reduction from 450 hp. to 72 rpm., or a ratio of 6½ to 1 between motor and drive shaft.

Couplings.

The coupling between the rotor shaft and the gear unit is No. 22 Francke flexible coupling bored in one-half 5 in. for the rotor shaft and in the other 5½ in. for the Fawcus gear shaft.

The coupling between the Fawcus gear and the bench line shaft is of the endless belt type and was manufactured here; Fig. 5 shows this coupling the No. 5 drawing bench. The bore in one half of this coupling is 6-13/16 in. for the Fawcus gear shaft and that in the other half is 5-15/16 inches for the bench line shaft. Each of these cast steel half couplings carries six 2½ in. diameter pins which project 6½ in. from the face; these pins are taper fitted and are held in place by a nut. The belt used in the coupling is three-ply leather, 6½ in. wide.

Control.

The control apparatus for the two motors, numbers 535 and 536, is all housed in a two-story brick building, seven feet wide by 18 ft. 4 in. long, inside dimensions. The secondary panels, which form the main part of the magnetic control equipment, are assembled as one continuous switchboard and located on the upper floor of the building. This board is 6 ft. 4 inches high by 16 ft. long. As the equipment carried on this board is all in duplicate a list of that required for one motor will suffice.

Panel 1 carries the following equipment:

1 three-phase, 2-coil indicating wattmeter.
2 inverse time limit overload relays, plunger type.
1 main oil circuit breaker, T. P. S. T., 4,500 volt, 200 amp., with overload trip coils.
1 undervoltage release.

Panel 2:

3 current limit relays.
1 D. P. S. T. 60 amp. control switch, with enclosed fuses.

Panel 3:

1 double pole, 75 amp. under voltage protective contactor.
2 triple pole, 150 amp. magnetic contactors.

Panel 4:

3 triple pole 150 amp. magnetic contactors.

Panel 5:

1 triple pole 150 amp. magnetic contactor.
1 triple pole 300 amp. magnetic contactor.
1 triple pole 600 amp. magnetic contactor.

The 600-amp. contactor is the only one of the eight triple pole switches which remains closed after the motor has been brought up to speed.

A view of the interior of the lower story of the control house is shown in Fig. 6. The magnetically operated oil immersed high voltage contactors, both front and rear views of which are shown, are for making and breaking the circuit through the motor primaries. These units were intended for reversing service, but since this feature is not needed in this case, the connections were made so that the motor runs forward when either one of the duplicate switches is closed.

In Fig. 1 a close up view of the master switch lever handle together with the maximum torque push button is shown located on the wall of the motor pit. The master switch, or hand controller, has six points forward and reverse, which may be used in accelerating the motor by hand, or the lever handle may be thrown at once in either direction and the magnetic starter will automatically take care of the acceleration. The motor runs forward in this case regardless of whether the controller handle is moved to the forward or reverse position. The "maximum torque button" is for use in event the motor may not develop sufficient torque to start with all the resistance in circuit with the secondaries; a touch of this button will close the third accelerating contactor and thus insure starting under conditions of excessive load.

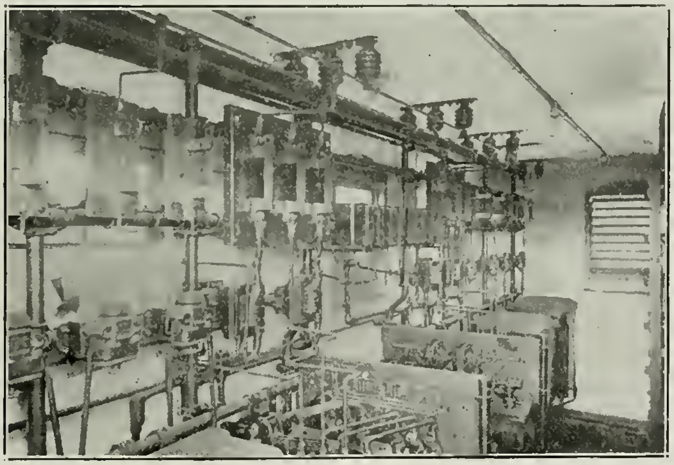


Fig. 6.

Safety Stop Buttons.

For each of the motors driving benches 5 and 6 there are two stop buttons; those for No. 5 bench are located on columns near each end of the bench; in the absence of columns along the side of No. 6 bench the two push buttons, one near each end of the bench, are each operated by a chain suspended from a lever supported by the roof truss overhead.

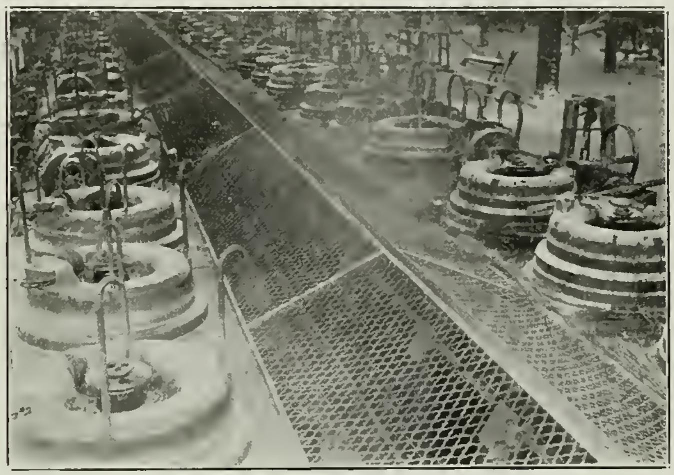


Fig. 7.

Pressure on one of these buttons opens the circuit through the coil of the under voltage contactor on panel 3 and this causes all switches to open instantly, stopping the motor, which will not start again until the master switch handle is returned to the "off" position.

The off position of the master switch serves to reset the under voltage protective contactor, and when the motor stops from any cause it cannot be started again until the master switch is returned to this position.

FRACTURE OF WIRE IN STEEL ROPE.

This was the subject of a paper recently read before the British Association by Dr. E. M. Horsburgh, in which the principles of examination and possible solutions of rope problems were involved. One section deals with the system of forces across a rope section, as compared with the forces in system of flexible cords sustaining a load. Another section deals with the rope modules and a method shown whereby an analytical expression might be fitted to curves. Other matters touched upon were the aggregate strength of rope wires, also experiments in combined stresses re tension with bending and with torsion. Attention was also drawn to fatigue tests, and mathematical grounds were given for inferring the existence of a fatigue stress. An instance was quoted, where, in the case of a rope which failed after 2½ years service, the unstressed and stressed portions were annealed, from which conclusive evidence was obtained of fatigue of the wire, and that the fracture was not due to sudden stress.

American Rolling Mills For France

Description and Layout of the Mills Recently Constructed by the United Engineering & Foundry Company and Shipped to the Acieries de la Marine et Homecourt of France.

AMERICAN Rolling Mill Practice is rapidly being adopted by France. Heretofore, the majority of French steel works produced a very wide range of products, the average order for each kind of product being small. On this account, the mills had to be adopted for this class of production and were mostly what might be called the jobbing variety. In other words, their problem was one calling for a variety of production rather than a large tonnage production.

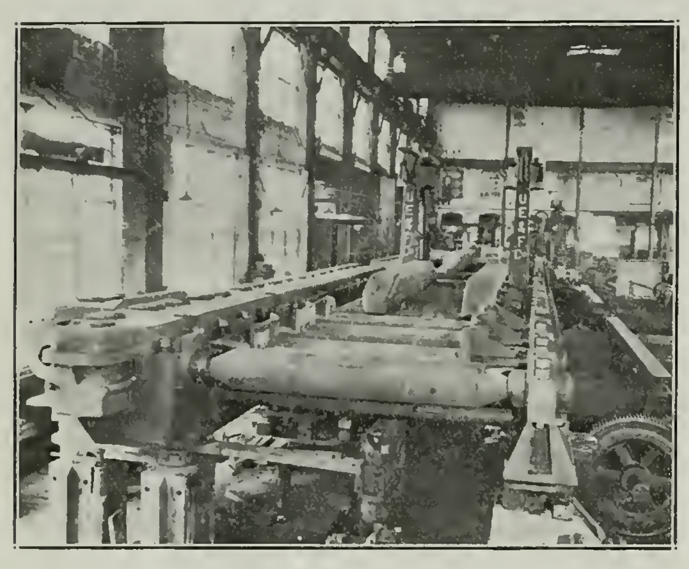


Fig. 1.

Since the war, France has acquired approximately one-third of the iron ore reserves of Europe. In order to take advantage of this situation and to promote as rapidly as possible the prosperity of France they are changing their methods and introducing specialty or tonnage mills. Instead of working independently, many of the steel plants of France have combined so as to avoid competing with each other. By this combining, they were enabled to devote entire plants to the production of a few lines of product—in other words, not only specializing mills but also specializing plants. A good example of this is contained in the Acieries de la Marine et Homecourt, France, wherein the Homecourt Plant will be devoted entirely to plates and small billets while the Micheville Plant will be devoted almost entirely to rails and structural material.

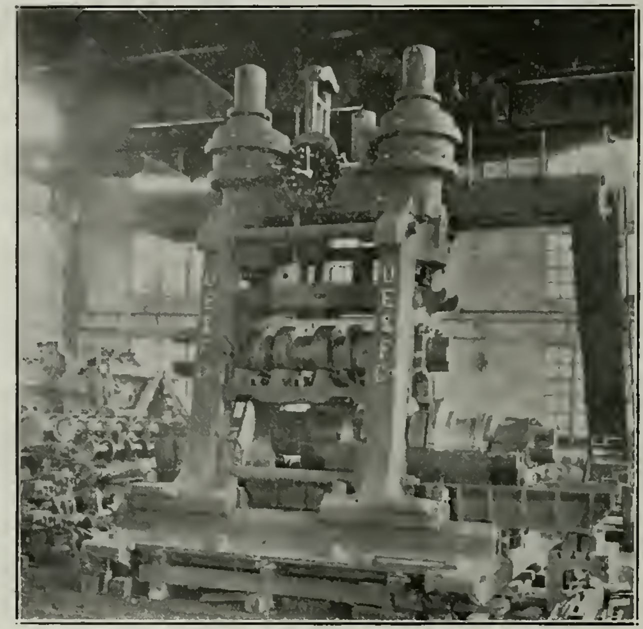


Fig. 2.

In 1919 this French combination placed with the United Engineering & Foundry Company of Pittsburgh, Pa., orders for five separate and complete units. For the Homecourt Plant 1—44 in. Blooming Mill and 1—48 in. Universal Plate Mill. For the Micheville

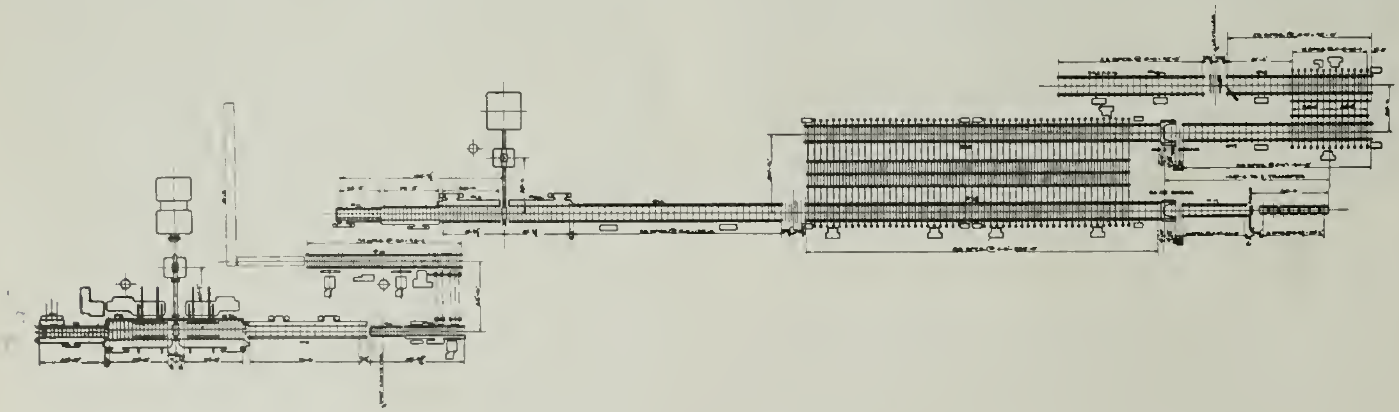


Fig. 3—The general arrangement of the 44 in. blooming and 48 in. universal mill for Homecourt.

Plant a 44 in. Blooming Mill, a Combination Rail & Structural Mill and a Cross Country Light Structural Mill. The mills for Homecourt are shown on small scale layout. The machinery is of the most modern type. The Blooming Mill is a 44-in. Reversing Type, a most noteworthy feature about it being its ability to roll slabs 50 in. wide. This Blooming Mill will roll slabs for a 48-in. Universal Mill and for a number of Plate Mills to be built in the future ranging from 84 in. up to 132 in. It will also roll blooms for a Morgan Continuous Mill.

The question of lubrication has become a very important one in recent years and the mill tables on this mill were designed especially with this end in view. Figure I shows the front and back mill tables being erected in the shop. By examining the photograph, you will note that the line shaft, gears and bearings are all enclosed in an oil tight case. The oil is pumped through piping to each bearing and set of gears. After lubricating the parts, the oil is collected and returned to a filtering tank where it is cleaned and used over again.

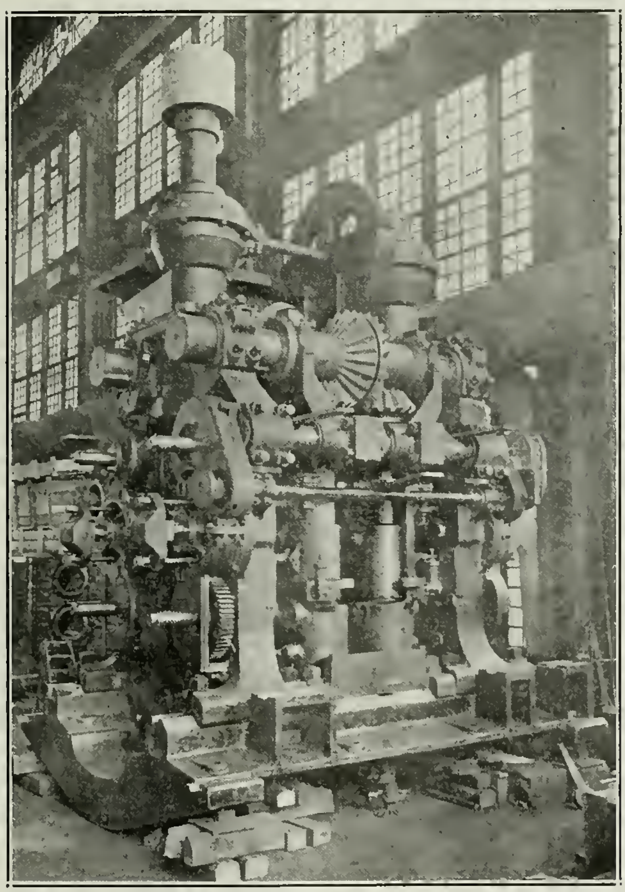


Fig. 4.

The 48-in. Universal Mill is of the 2 High Reversing Type and is shown on Figure 4. It was designed to cover a wide range of universal plate and will roll these in sizes from 11 in. to 48 in. wide. It was also arranged to be used as a reversing plate mill. The vertical roll attachments were especially designed for rapid removal so that the mill could readily be changed from a universal to a sheared plate mill.

The layout of the auxiliary machinery for both the blooming mill and the universal mill are indicated on

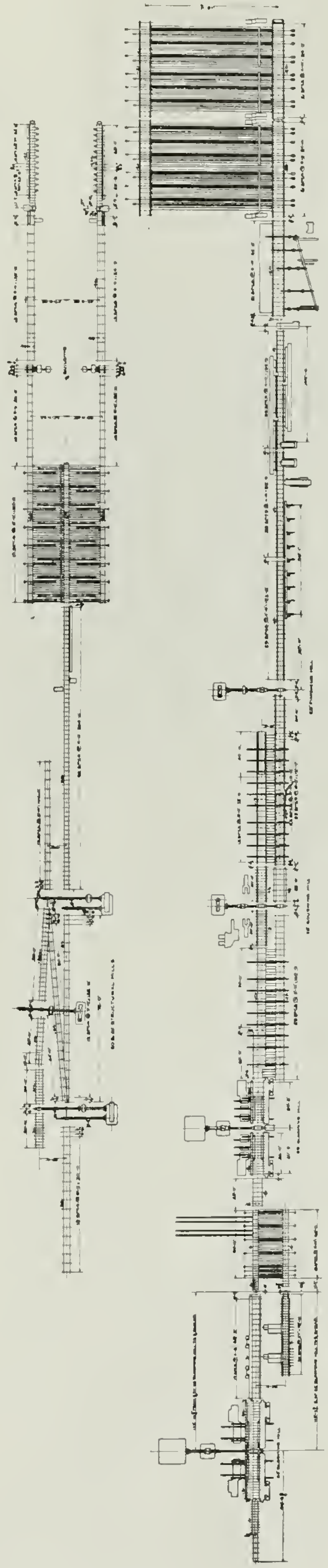


Fig. 5—General arrangement of the 44 in. and 36 in. blooming mills and 28 in., 20 in. and 24 in. structural mills for Micheville.

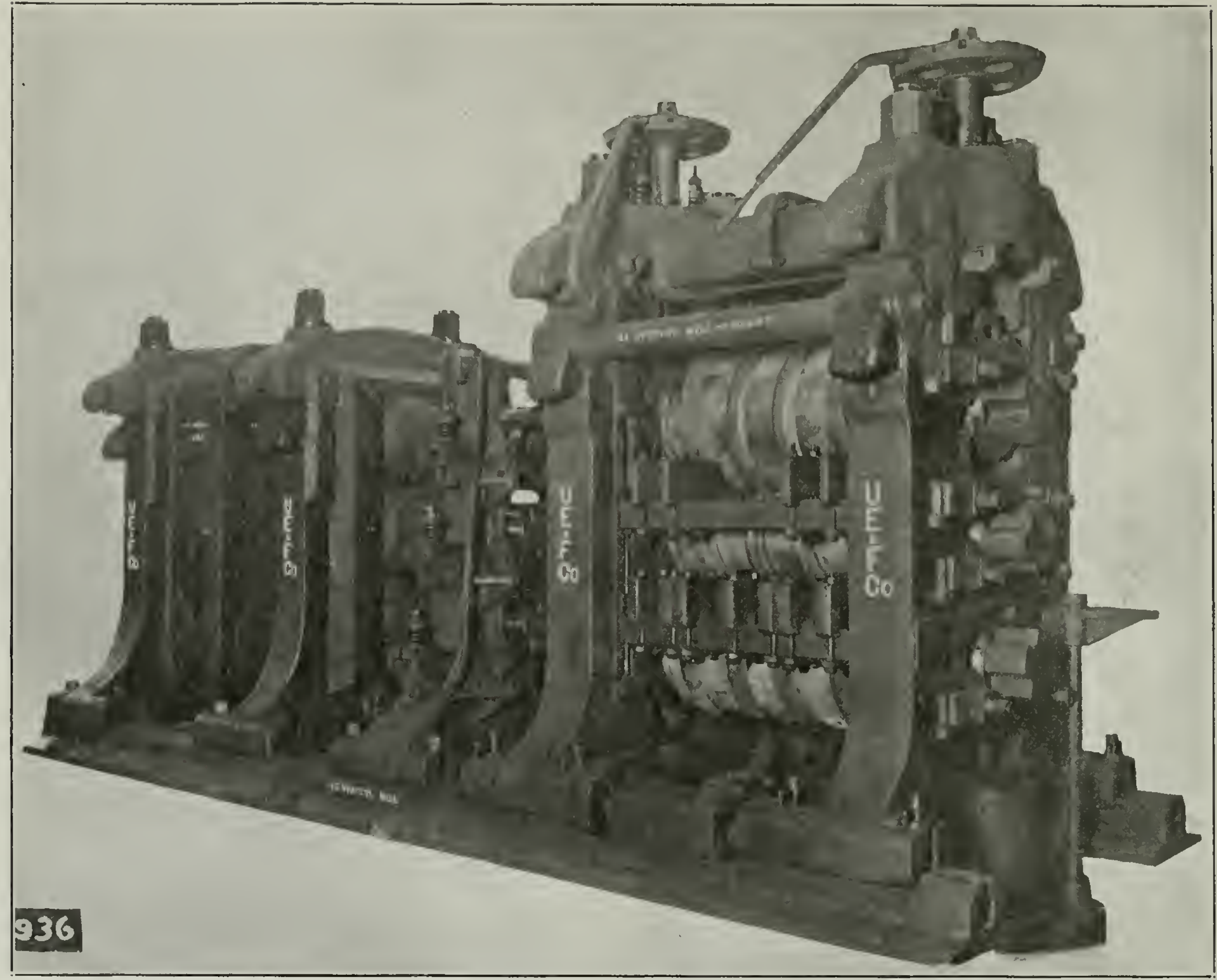


Fig. 6—General construction of light structural mills.

the small plan. The structural mills for Micheville are shown on the small scale layout. The blooming mill is a 44-in reversing type, duplicate of the one for Homecourt with the exception of the shear and bloom handling equipment. The combination rail and structural mill which is set tandem to the 44-in. blooming mill consists of a 2 high reversing 36-in. roughing stand, 28-in. 3 high stands of rolls and 1 stand of 28-in. 2 high finishing rolls. The general design of the 44-in. blooming mills and 36-in. roughing mills are shown on Figure 2. They all consist of the "United" Patent A Frame Housing. The 36-in. roughing mill possesses one feature different from the blooming mills and that is the method of changing rolls. On account of being used as a roughing stand for rail and structural material, the bottom roll must have very large collars. It has been the past practice to make roughing mills of this type with removable caps or else the windows of the mill had to be very wide in order to remove the rolls. By the construction shown in the illustration it was possible to use a solid top housing and a mill with a very narrow window. The bottom part of the window has an opening large enough to allow the roll to pass through. The roll is shown mounted in its bearings, partly withdrawn from the mill. By this construction, a simple, sturdy mill is obtained, rapid roll changing is accomplished, short roll lengths are permitted because several passes can be taken through the same groove in the roll due to the fact that the top roll can be adjusted for each pass by means of the screwdown. The 28-in. mills are equipped with all the latest handling and manipulating devices that have been invented up to the present time for the rapid and automatic handling of rail and structural materials. The light structural mill consists of 1—3 high stand of 24-in. rolls, followed by a 2 high 20-in. edging stand, followed by 2—3 high stands of 20-in. rolls, followed by 1 stand of 2 high 20-in. finishing rolls. The 24-in. stand is equipped with lifting tables and "United" Automatic Manipulator. The general type of the mill is similar to the one installed at the Clairton Steel Company in this country. It is equipped with double hot bed and double finishing end for the rapid handling of light structural material. Angles, flats, small beams and channels will be its principal products. The mill is also arranged to roll light mine rails 40 lb. and under. The general construction of the 28-in.—24-in. and 20-in. mills are as shown in Figure 6. The rolls and guide equipment was furnished complete. All of the auxiliary machinery, such as tables, transfers, shears, hot beds, levelers, etc., were designed and built complete.

The Mansfield Sheet and Tin Plate Company's New Steel Unit

This Company Is Now Completing Its Steel Making Plant Consisting of Four Open Hearth Furnaces, Soaking Pits, a 32-Inch Mill and a 24-Inch Sheet Bar Mill.

By CARL W. PEIRCE*

ABOUT seven years ago the old National Rolling Mills Company at Mansfield, Ohio, was taken over by W. H. Davey and his brothers, remodeled and in three months time was engaged in the manufacture of steel sheets under the name of the Mansfield Sheet & Tin Plate Company. The old concern, which consisted of three hot mills, housed in a building 67x140 feet, had only operated for a few months before it was compelled to shut down and never operated afterward as the National Rolling Mills Company.

Under the management of Mr. Davey and his seven brothers, all of whom were practical sheet mill men, the new company was successful from the start.

From time to time additions were put onto the old plant so that today the building is 167 feet wide by 940 feet long and houses seven tin mills with their accompanying equipment.

Early in the year 1917 ground was broken for a new sheet mill unit which was located south of the old plant and on the other side of the Pennsylvania railroad tracks between the railroad and Bowman street. This plant, which was built mainly for the manufacture of high polished sheets, was designed and built under the supervision of Mr. Austin Davey, chief engineer of the company. The building, which houses 12 sheet mills with their pickling, annealing and cold roll departments, is 226 feet wide by 1,039 feet long. This plant was put into operation in the fall of 1919.

On account of its inability to get a satisfactory delivery of sheet bars, the company in the fall of 1919 began to consider the advisability of building their own steel making unit. A piece of land lying between the B. & O. and Pennsylvania railroads and joining the company's property was occupied by two hills which it was necessary to remove. It was selected on account of its railroad connections and its proximity to the other two parts of the plant.

In March, 1920, the Fred R. Jones Construction Company with three steam shovels started to prepare the site for a steel unit large enough to produce what bars the sheet and tin mills would consume and the work of designing the unit was begun. This work was done by Mr. F. A. Davey, chief engineer, and Mr. Carl Pierce, open hearth superintendent, with Mr. Frank I. Ellis of Pittsburgh as consulting engineer. Mr. J. Coursin was in charge of the field work.

Plans were drawn for an open hearth of four 80-ton furnaces with covered stock houses and a rolling mill department consisting of soaking pits, a 32-inch mill for breaking down the ingots and a 24-inch sheet bar mill. On account of the product of the mills being mainly high polished sheets, it was the desire of the president of the company that the steel should be poured by the bottom-cast method in order to guarantee a high grade sheet bar.

The general layout plan shows the relation of the steel plant to the tin mills and of the open hearth and rolling mill units indicating in dotted line the future furnace extensions.

In view of the peculiar shape of the land it was early decided to leave a part of the hill on the west side of the property and place the stock yard upon it, bringing it on a level with the open hearth charging floor and parallel to that building. In making the crossovers from the stock yard to the open hearth a new arrangement has been used. Instead of pulling out from the end of the stock yard and entering the charging floor at the ends, a double crossover track extends from each end of the stock yard and crosses to the opposite end of the charging floor, the crossovers connecting with the furnace track between furnaces Nos. 1 and 2 and between 3 and 4. The advantage of this type of construction is that the stock yard engine is able to deliver a drag of loaded pans on the furnace track over one crossover, then back down the floor and remove the empty pan cars to the stock house over the other crossover, performing the two functions by the one shift. By this arrangement, too, it is impossible to have a furnace blocked from charging because another furnace between it and the stockhouse inlet is being charged, as the charge can come in over the other crossover.

The buildings furnished by the McClintic-Marshall Company are of strong, sturdy construction in keeping with the other equipment of the plant. In the stock yard building, which is 77 feet wide by 300 feet long, is a 20-ton crane for loading the charges. The first two bays at the south end of this building are occupied by large concrete bins for the storage of limestone, raw dolomite, and iron ore. Two tracks run through the east side of the building, the one nearest the open hearth being used for loading the charging pans and is on a level with the charging floor; the other track used for loading is four feet lower. This arrangement brings the tops of the gondola cars of scrap and the charging pans on the same level. This latter track being four feet lower than the loading track decreases by this amount the grade of the track leading from the mill level into the stock house. On the brow of the hill outside the stock house and between it and the open hearth are two tracks, one being used as a storage track, the other nearest the stockhouse as a run around track in going from one end of the stock

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*Mr. Peirce is open hearth superintendent for the Mansfield Sheet & Tin Plate Company.

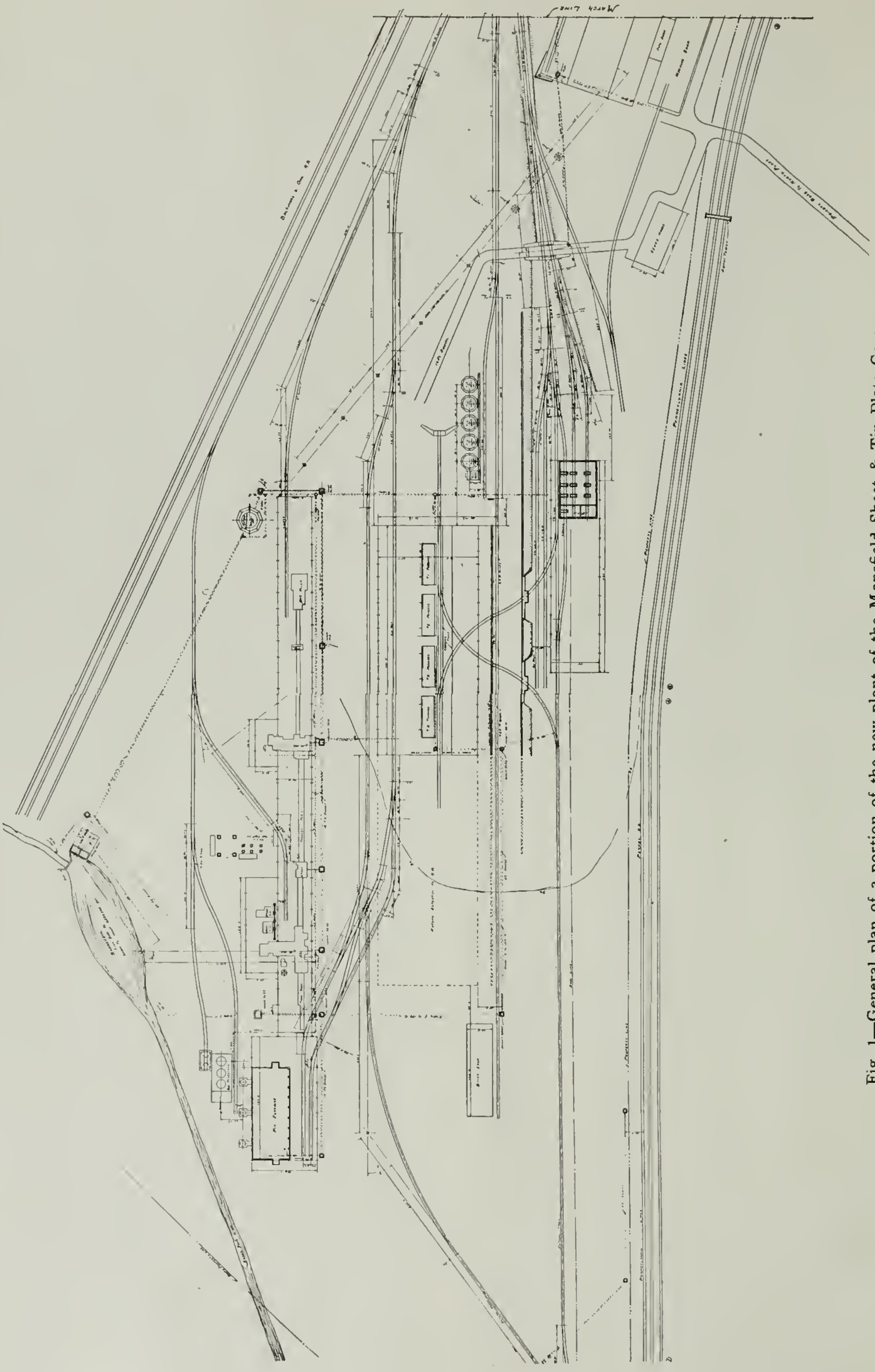


Fig. 1—General plan of a portion of the new plant of the Mansfield Sheet & Tin Plate Company.

house to the other. A 75-ton two-section scale with self-indicating Weightograph attachment furnished by the Buffalo Scale Company, Buffalo, N. Y., and located on the loading track midway between the crossovers will weigh all charges. A 150-ton 4-section railroad track scale, furnished by the same company, is located in the yard between the north plant and the B. & O. railroad. The charging pan and ingot cars, furnished by the Pittsburgh Steel Foundry Company, are of skeleton steel casting type equipped with Hyatt Roller bearings and with a patent coupling device designed by the foundry company. These cars, in addition to all mill cranes and run out tables, will be lubricated by the Adkins Lubricating System, Canton, Ohio.

Between the stock yard building and just outside the valve cellar wall of the O. H. is a depressed track to allow for passage of cars under the crossover tracks leading from the stockhouse to the O. H. Space has been left on the mill level between the depressed track and the stock house for a future installation of gas producers. The depressed track also permits the wheeling of dirt directly onto the cars when the furnace regenerators are cleaned or for the removal of ashes from the gas producers.

The open hearth building housing the four 85-ton furnaces is 360 feet long, with a pouring aisle 65 feet wide and a 25-foot leanto over the valve cellar. The charging floor which is 16 feet above mill level has its furnace track 6 ft. 6 in. center from the front of the furnace, permitting the passage of standard gauge cars over it. This arrangement permits the dumping of iron ore and limestone through the tail trestles at each end of the charging floor and will permit the unloading of a car of brick at a furnace when it is under repairs.

The 85-ton O. H. furnaces which are being built by the S. R. Smythe & Company, Pittsburgh engineers and furnace builders, are at 80-foot centers in the building and are 65 ft. 3 in. long over the brickwork, having a hearth 15 ft. by 35 in. by 5 ft. deep. They have been designed to burn either oil or natural gas as fuel. They will be started out on oil, five 100,000-gallon tanks having been provided for oil storage. The furnace hearths are supported upon two piers 8 ft. 7½ in. by 17 ft. 7½ in. by 15 ft. 3¼ in. high placed 19 feet apart. These piers are made of 18 inches of wire cut brick on the outside and the center filled with concrete. On these piers are placed ten 20-in. 80-lb. beams with 12-in. cross channels, the channels forming the bottom of the pan upon which the hearth is built. The chills at the end of the hearth are made of plates and angles properly braced.

The buckstays supporting the hearth and roof are made of 15-in. beams and channels, the latter reinforced by one-inch plates riveted to them. The front and back of the furnace pan between the buckstays is made of heavy iron castings properly ribbed. The door castings are designed with the front corner cut away for the installation of a 4-inch water line to care for the waste water from the doors, this arrangement providing for a very short connection from the door to the telescope pipe.

The port-ends and regenerators are bound with 12-in. beams and channels properly reinforced. The furnace regenerators are 22 ft. 10½ in. long and 9 ft. high from the top of the rider walls to the square of the arch, the gas chambers being 7 ft. 1½ in. and the air chambers 12 ft. 10½ in. wide with a 3-foot wall between them. The flues leading from the regenerators to the valves are of the standard design for 36-in. gas and 42-in. valves of the Blair Engineering Company design with which the furnaces are equipped. Waste heat boilers of 500 hp. each and built by the Erie City Iron Works, Erie, Pa., have been installed on furnaces Nos. 3 and 4, for utilizing the heat from the waste gases from the furnaces, 60-in. Blair valves making the connections between the furnaces, the boilers and the stacks. Mechanical draft for the boilers is furnished by 7 ft. 6 in. Sturtevant fans driven by steam turbines. The fans and turbines are located on the lean-to floor adjoining the boilers.

The furnaces are provided with five electrically operated charging doors of the Knox water-cooled type, the middle door opening being 48 in. wide by 45 in. high, the others being 42x42 in. The motors and drums controlling these doors are located on platforms underneath the charging floor and just back of the regenerators.

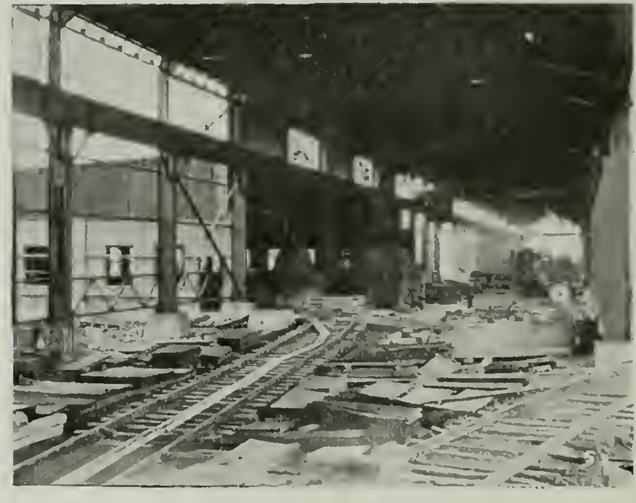
A 5-ton high type charging machine of Alliance Machine Company make with track span of 14 ft. 6 in. has been installed to charge the furnaces. This machine is designed with a two-foot clearance between the charging rails and the lower framework of the machine. The furnace aisle has been designed for the future installation of an overhead crane.

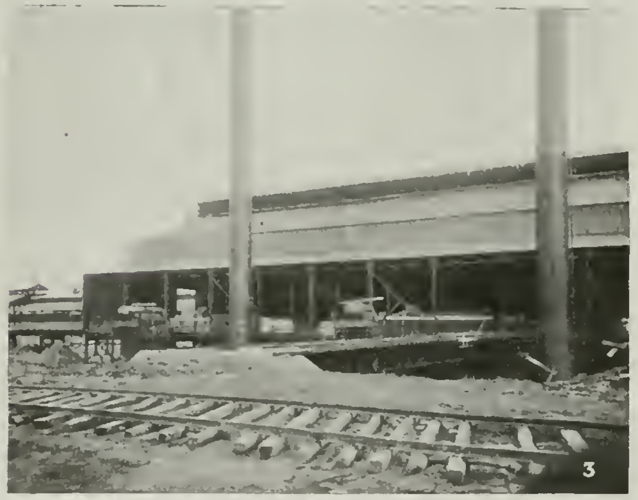
The charging floor between the furnaces slopes gradually to the platform behind the furnaces which is on a level with the tapping hole platforms. Six-ton electric jib-cranes furnished by the Pittsburgh Crane & Equipment Company are at the back of each furnace for the removal of the tapping spots, which are of the V-shaped steel casting type.

On account of the steel being poured by the bottom cast method, the pouring aisle is traversed by only one track which will serve alike for the removal of ingots to the pits, the east side of the building, on the floor in front of which are placed the pouring plates. These plates are 8 ft. 4 in. square and designed to permit the pouring of 12 14x15-in. ingots from one fountain. Five plates will be required to handle the output of each heat, the two pouring platforms being long enough to accommodate 25 pouring plates. Between the two platforms is a hydraulic stripper for pushing out sticking ingots. This stripper is equipped with a motor driven pump, making it a self-contained unit. The 90-ton ladles of modern design with sloping bottoms and the nozzle at the lowest point were made by the Treadwell Construction Company, Midland, Pa.

The pouring aisle is provided with a 125-ton main hoist ladle crane with a 25-ton auxiliary trolley, and a 5-ton stiff-leg crane of the soaking-pit type, both of Alliance Machine Company make. The stiff-leg crane was designed to be able to strip molds from the ingot, twist the latter from the bottom roots and pile on the cars for delivery to the soaking-pits in addition to setting the molds back on the pouring plates. This method of handling bottom-poured ingots guarantees their delivery to the soaking-pits as quickly as though they were top-poured.

The overflow of slag from the ladles will be caught in large steel casting boxes of the truncated pyramid type, having a capacity of 165 cubic feet and placed on the floor alongside the ladles. After the slag is sufficiently cooled for transportation, the box with its contents is placed on a specially designed side dump car large enough to hold one slag chunk, the box is then stripped from the chunk, leaving it on the car ready for transportation to the slag dump. The small dirt will be handled in 12-yard side sump cars. A grinding house with heavy duty 9-foot pan is on the mill level and joins the pouring aisle at the south end.





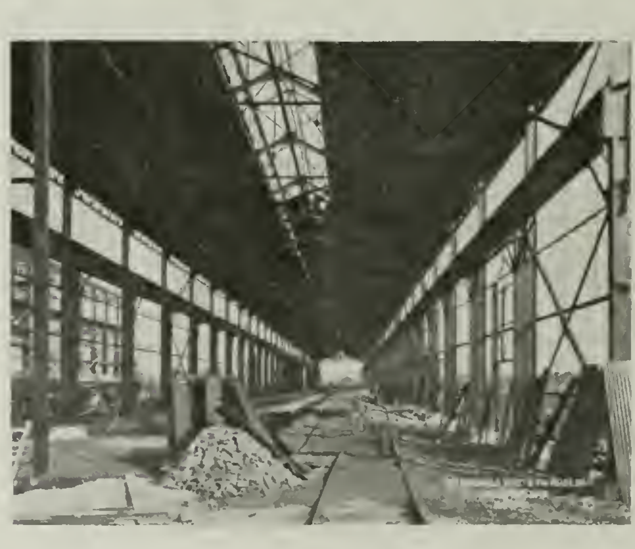


Fig. 1—Stock house, open hearth building and rolling mill building.

Fig. 2—View of mill building showing stand pipe under erection and soaking pits and gas producer buildings in background.

Fig. 3—View from stock yard scales showing one of cross-overs, waste heat boilers and soaking pit and mill buildings in background.

Fig. 4—View of mill showing bar piler in foreground, 1"x8" shear, and 24" slick mill in background.

Fig. 5—View of interior of the mill building.

Fig. 6—View through bar mill building before starting the erection of mills.

At the south end of the pouring aisle and at a level with the top of the crane girders is a repair platform, arrangements having been made for the future installation of a mono-rail and crane for serving cranes in both the charging and pouring aisles. An escape platform has been provided for the ladle crane operators above the pouring platform and on a level with the crane cab, extending the entire length of the building. This platform has a runway outside the building with steps leading to the ground to allow operators to escape in case of a bad spill.

From the pouring aisle, the ingots are taken to the soaking-pit building which with the mill building lies to the east of the open hearth and runs parallel to it, a space of 100 feet separating the open hearth and mill buildings. The soaking pit building, which is 192 feet long by 77 feet wide, and with a 20-ft. lean-to over the valve cellar, houses three pit furnaces of four holes 5 ft. 6 in. by 8 ft. each, built by the Smythe Company. The arrangement of the pit holes is opposite to that of the usual design, the 12 holes being in line with the length of the building, the covers being designed to back into the lean-to building when open so as to be out of the way of possible damage from the crane. This arrangement also permits the use of a tunnel running under the line of the 12 pits, which is served by track, slag cars and boxes. Between each two pits is an opening for the removal of the slag boxes by the crane. The pit covers are operated by a special design of a shaft driven by a motor with a separate clutch for each cover. By this arrangement one motor will operate the four covers of each furnace. These furnaces are designed to operate without regenerating the gas, no checkers being placed in the gas chambers and all outgoing gases passing through the air regenerators. These furnaces are very strongly reinforced with three sections of 20-in. beams with 9-in. vertical channels. The bottom structure of the pit holes consists of 2-in. cast iron plates resting on 12-in. beams. The valves are of the ordinary butterfly type. The stacks are self-supporting and are 4 ft. 6 in. in diameter and 120 ft. high.

At the east of the soaking pits and at the rear of the stacks is a gas producer building housing three 10 ft. 6 in. stationary producers equipped with direct drive Chapman agitators built by the Chapman Engineering Company, Mt. Vernon, Ohio, which will furnish gas for heating the ingots. Over each producer is a large steel coal hopper of 50-ton capacity, served by a 5-ton Northern crane and grab bucket. The coal is delivered to the gas producers over a trestle from which it is dumped into a hopper, crushed and conveyed to a bin under the gas producer crane. The single roll crusher and belt conveyor are of standard design and built by the Webster Company, Tiffin, Ohio. Between the soaking-pit stacks and the gas house cellar is a depressed track which permits the wheeling of the ashes directly onto a side dump car.

In the soaking-pit building and to the west of the pits are three tracks, the two on the outside for the delivery of ingots from the open hearth and the one nearest the pits for the ingot chariot. This building is served by a 5-ton standard type soaking pit crane of Alliance Machine Company make. From the pits the ingots are carried by a motor driven chariot, built by the United Engineering & Foundry Company, and delivered on the approach table leading to the 32-in. mill which is of the 3-high type built by the Wm. Todd & Company, Youngstown, Ohio.

The motor driving this mill is a 2,000-hp. 240-rpm. 2,200-volt a.c. type of General Electric make, the power passing through a 20-ton flywheel, a 5 to 1 reduction gear built by the Morgan Construction Company, then through the pinion housing to the rolls, the hydraulic lift tables are operated by an Aldrich 600-lb. pressure pump and accumulator, the table on entering side being served by a manipulator car with fingers for turning the ingots.

The 14x15-in. ingots will be reduced in 11 passes, the last an edging pass to 2½x7¾-in. bars, after which they pass to an 8x8-in. motor driven Mesta shear, from which the cut bars pass to a 24-in. Slick patent sheet bar mill made by the United Engineering & Foundry Company. The runout tables between these mills, the rolls of which are equipped with Hyatt roller bearings, were made by the Woodard Machine Company, Wooster, Ohio, and lubricated by the Adkins System, Canton, Ohio.

The 24-in. mill motor is of a 2,500-hp. 240-rpm. 2,000-volt a.c. type, also of General Electric make, the power passing through a 40-ton flywheel, then through the reduction gear and pinions to a 3-high stand in which the bars make four passes, being carried from the lower to the upper passes by a series of chutes which form the basis of the Slick patent. From the final pass in the 3-high the bars are shoved over to the final pass in the 2-high stand by a hydraulic arc. Both stands of rolls in this mill are in line and run by the one motor.

The bars after leaving the 24-in. mill are conveyed by pinch rolls and chutes to a 1x8-in. shear made by the Cleveland Punch & Shear Company and from there to a Kennedy bar piler made by the United Engineering & Foundry Company. Ample cooling beds occupy the space between the bar piler and the end of the building. The mill building, which is 850 feet long by 55 feet wide, is served by a 25-ton and a 10-ton crane of Alliance Machine Company make.

The control on all cranes has been furnished by the Electric Controller & Manufacturing Company, Cleveland, Ohio, the general control by the Westinghouse Company, all small motors and main switchboard by the Westinghouse Electric & Manufacturing Company. The yard work is served by a 20-ton, 50-ft. boom McMyler crane and a 40-ton saddle tank American locomotive. In the general layout of the plant, attention has been given to sewers, water and power conditions. A 36-in. reinforced concrete sewer into which empties two 24-in. sewers from the open hearth and mills and running west from the creek across the north end of the future extension of the open hearth will care for all waste water. A concrete dam with two 4-ft. flood gates has been placed in the creek near the B. & O. tracks, and the creek widened above the dam to accommodate a water storage of 6,000,000 gallons. In the pump house adjoining the dam are two 10-in. 2,000 per minute Manistee centrifugal pumps which pump the water through a 12-inch line to a 300,000 gallon standpipe located at the south end of the bar mill building. All water will be measured through a Venturi tube, giving an accurate estimate of the total water consumption.

In the 32-in. mill motor room has been installed a 600-kw. motor generator set of General Electric make and a 400-kw. steam generator set to insure sufficient power to operate all cranes in case the power should be shut off by our outside source of supply.

The output of the mill unit, which will consist mainly of high grade sheet bar for the manufacture of high polished sheets, will be approximately 10,000 tons of bars per month.

given to the elimination of hand labor by the substitution of machinery and labor saving devices. The location of the plant, too, is particularly well chosen as it has railroad connections with three trunk line roads, the Pennsylvania railroad, the the B. & O. and the Erie, and as it is the only steel making unit in the district lying north of Columbus and between Cleveland-Canton on the east, and Gary, Ind., on the west, it has a marked advantage in freight rates on the steel scrap produced in this district. It is also close to its supply of pig iron, limestone and coal. Its operation should add much to the industrial life of Mansfield.

The Influence of Furnace Design on Quality and Cost of Product

THE ultimate cost of a finished product of given quality is governed by the cost of operation as influenced by the rate of production.

Because of the many variable factors governing the quality and cost of product, the selection of furnace equipment and the selection of fuel, consistent efforts to reduce cost of production require a thorough study of heat-treatment methods, manufacturing requirements and plant conditions.

The influence of furnace design on the quality and cost of product is illustrated by the diagrams which are example from actual practice.

These diagrams illustratė the economy attainable by the use of furnaces of improved design, the selection of which is based upon an intelligent study of the manufacturing problem as a whole. They also illustrate the economic weakness of the far too common practice of basing selection only on price or form of fuel, equipment or labor; quantity of output; temperature control, etc., without reference to other equally essential factors.

There are no fixed standards determining definitely the proper form of equipment or fuel. Each must be selected with reference to the other, and the combination adapted to the heating process, manufacturing requirements and plant conditions.

Frequently it is possible to better the quality of product by adapting an improved method of heating or cooling to existing conditions. A different type or arrangement of furnace equipment may decrease labor, fuel and time; utilize the floor space to better advantage; and provide more comfortable working conditions. This generally results in an increased output and lowered production cost even with the same unit prices for fuel, labor and power, without necessarily requiring new building construction.

Requirements for quality should determine the method of heat application. With this as a basis, the production requirements and plant conditions should determine the type, size, number and arrangement of furnaces; the form of fuel or electrical energy; and the methods of routing and handling the material.

It is a common but misleading assumption that control of chamber temperature or of heat supply is synonymous with control of heated product. On the contrary, control of the generation of heat is not equivalent to control of the application of heat, or to control of the uniformity of product. Other essential factors influence quality and ultimate cost of production.

The comparative ease of controlling electricity, gas or oil is frequently considered as the determinative factor in the selection of heating equipment, regardless of a material difference in price of other forms of heat energy or equipment.

Automatic control of the delivery of coal through stokers or in powdered form; of gases, oil or steam through automatic valves; or of electricity through various forms of regulating devices, may result in control of the generation of heat, but does not necessarily determine the use made of the heat.

The question of control involves: Control of supply of fuel to the furnace; control of supply of heat to the working chamber; and control of heat actually applied to the product. The influence of furnace design upon the application and utilization of heat in the product is far-reaching.

There is a radical difference between the arc, induction, and resistance methods of generating heat by electricity. There is even a distinction within each of these broad groups. With the resistance method, for example, the heat may be generated by means of metallic resistors distributed on the walls of the furnace or by other forms of resistance material the nature of which prohibit such distribution. In each instance the furnace design must be adapted to the method of generating and delivering heat to the working chamber.

It is thus apparent that the practice of associating a given form of fuel or electricity with quality or low cost of production is misleading, unless there is definite reference to the form of furnace and method of heat application.

This fact may be illustrated by an unusual case which involved a comparatively efficient type of furnace fired manually with bituminous coal, and three less efficient furnaces, one fired with oil, another with natural gas and the last heated electrically through metallic resistors with suitable control devices. With all other conditions alike, it was conclusively proved that the quality and cost of the product were most favorable with the coal-fired furnace.

This example, however, does not prove that any one method of generating heat is superior. In this instance the difference in results was due to the better design and operation of the coal-fired furnace, and the manner of applying and utilizing the heat. In one case, the apparent disadvantage of a crude form of fuel was overcome by an efficient furnace, while in the others the apparent advantages of the more flexible forms of fuel, and particularly the advantage of electricity with control devices, were neutralized by inefficient furnaces.

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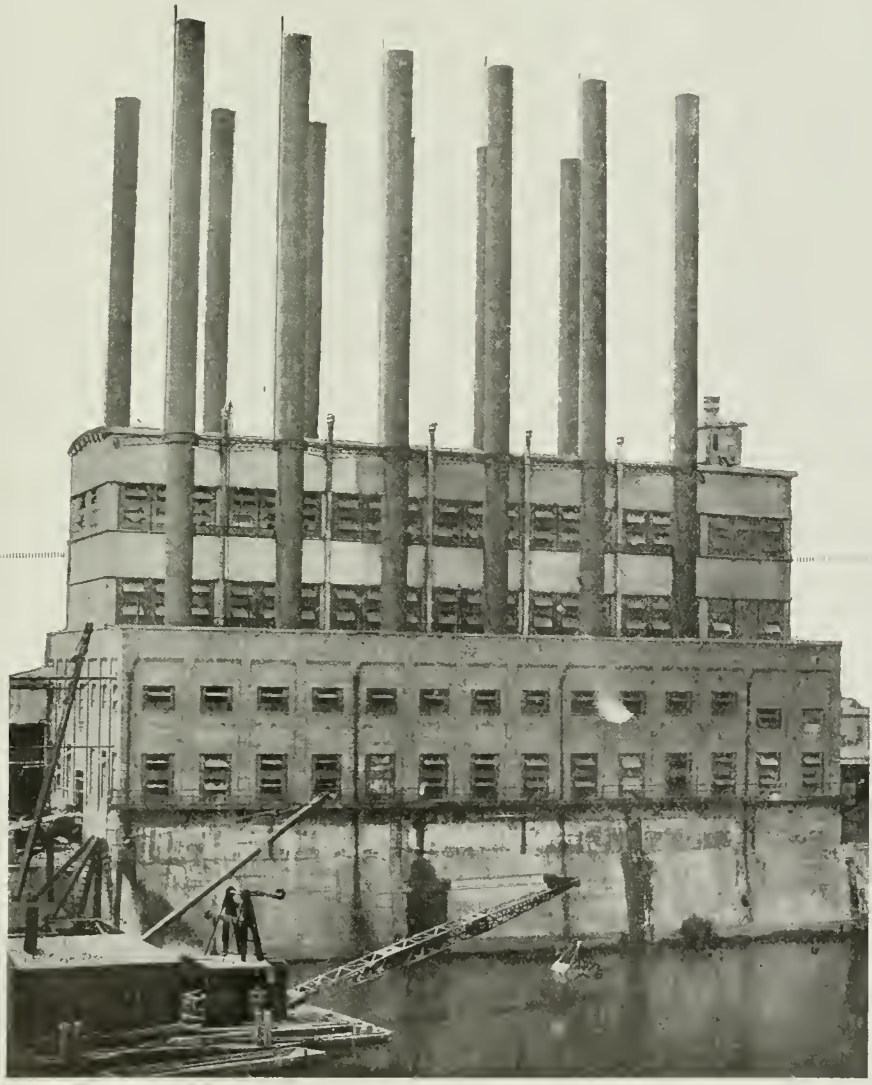
Power Department

Power in the Steel Industry During 1921
By F. J. CROLIUS

Sloss-Sheffield Steel and Iron Company's Steam Generating Stations
By M. M. ARGO and H. MAULSHAGEN

The Influence of Gas Cleaning on Plant Economy
By WALTER N. FLANAGAN



Power in the Steel Industry During 1921

During the Year Power Developments and Improvements Were Made and Future Improvements Were Authorized—Steam Power for Steel Plants Must Be Centralized into Single Large Stations.

By F. J. CROLIUS, Steam Engineer
Homestead Works, Carnegie Steel Company, Munhall, Pa.

THE year 1921 will long be remembered in the steel industry as one of acute contraction, sharp reduction in output, high comparative production costs and forced economies. Wastes of labor, materials, time and fuels stood out in stark contrast when charged against curtailed output. Power, which has always been relegated to the background, an undesirable necessity, a mere means to an end, was brought vividly into the foreground, as a function of extreme importance, worthy of constructive thought, a definite source of profitable recovery.

Looking back upon 1921, our impression is one of a long delayed, much desired "breathing spell when, after a mad race against time and production, we are given a chance to breathe and think and recover equilibrium, a chance to strengthen our fabric for the continuance of the competition.

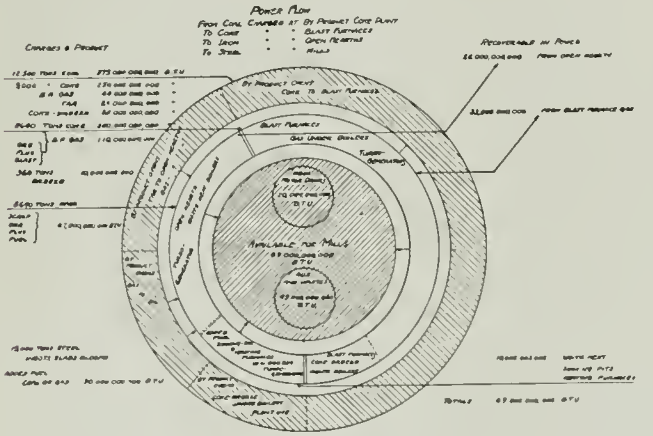


Fig. 1—Heat balance (Colfax).

And so, through the mists of depression, the sun shines forth through a number of defined tendencies, and though production was at times and places nearly stagnant, though facilities for production remained constant, power developments and improvements were "carried on" and further developments authorized.

A glance at the general power field will indicate the reasons for these influences.

Two major forces have been at work, the forces of distribution and the forces of concentration. The steel plant has been developed mainly under the forces of distribution.

Steam driven power units of comparatively small sizes could be operated advantageously in scattered units.

Blast furnace gases were utilized locally, waste heat recoveries were widely scattered small individual sources. Coke recoveries were deemed unimportant.

These widely distributed points of generation lent themselves to the super-power idea, but as a *heat-balance* the unrecovered exhaust presented a problem difficult of immediate solution.

Tieing together distributed sources of steam generation through long steam lines, while utilizing the benefits of super-power in averaging out the load, imposed the constant penalty of high condensation losses, and subjected the total system to the *minimum* pressures on that system.

The advent of the motor drive pointed the way to a solution.

The forces of concentration then became operative in the steel industry, and the influences which have made central station practice an accepted standard bore fruit. It became clearly recognized that the same kind of steam must be produced in steel mills as in central stations.

Where before steam making was a mechanical art, today steam power production is approaching an exact science, the era of the heat-balance has arrived.

When the full force of this concentration of power has been developed and applied a revolution in steel and iron will have been effected.

At this point it may be relevant to visualize a typical heat-balance of the most modern power-plant—the Colfax plant of the Duquesne Light Company. (Fig. 1.)

Analysis of this will indicate the values of recovered wastes—for therein lies the secret of heat-balance.

Applied to the steel and iron industry, this form of comparison brings forth a number of significant facts, certain recoverable wastes are enormous:

1. Wastes from coke produced in other than by-product ovens.
2. Wastes from steam produced in small, inefficient boiler units.
3. Wastes from steam utilized in small, inefficient engine units, and high pressure steam used in heating.
4. Wastes from steam driven equipment—replaceable by motors.
5. Wastes of water by leaks and misuse, necessitating excess pumpage, and the pumping of water by wasteful steam units.
6. Wastes of valuable heat-units in metallurgical processes.
7. Wastes of exhaust steam and heat from condensers.

Space does not permit detailed discussion of these several known evils, nor is it even necessary to point them out to engineers. Constant reiteration may serve to draw attention to them. Few seem to realize their magnitude, however. Fig. 2 is an attempt to present a picture of recoverable wastes in the sequence of iron and steel processes. As a basis, a given amount of coal is charged at by-product ovens; the recovered coke is charged to produce its normal iron equivalent.

This iron, with a normal mix of scrap, ore, fluxes, etc., is charged in the open hearth to produce its average tonnage of steel ingots. The fuel fired is by-product tar and gas. These ingots are charged into soaking pits and reheating furnaces, and rolled in the mills to average practice of plates, shapes and blooms, the fuel used for heating is producer gas or pulverized coal, which must be added.

The power to operate is generated in boilers at various points, at coke ovens, fired with coke breeze; at blast furnaces fired with blast furnace gas and coke breeze; at open hearth, fired with waste-heat gases; and at heating furnaces, fired with waste-heat; this boiler steam through turbo-generators at various points—all mill units driven by motors.

Nothing empirical is suggested—all values are definitely known, all factors used are standard practice, but of course best practices have been selected at every point.

What this means when magnified to totals for the furnace coke industry can be expressed in a few paragraphs:

About 30,000,000 tons of iron is a fair annual average production. This means that some 50,000,000 tons of coal must be coked. About one-half this total is still produced in old-fashioned bee-hive ovens, from which nothing else is recovered but the coke; the available ammonia, the tar, the gases, which analyze into benzol, toluol, etc., are allowed to waste, to do no more than pollute the surrounding territory.

Within recent years we have been made to realize that we must recover these most valuable contents of the coal, or remain dependent for dye-stuffs, fertilizers, etc., upon some other nation whose necessities demand their recovery, and which nation has benefited at our expense thereby.

Just how busy *wasting* our "busy little beehive ovens" have been during their recent past is shown by the monument they have erected over their dead and worked-out mines; in the operation of drawing and screening the coke, a small percentage is broken off into fine pieces; this broken stuff is called braize, or coke-dust. It lies everywhere throughout the region where it has been allowed to accumulate until now the piles are estimated to contain millions of tons. The Btu. value of such coke dust approximates that of anthracite coal, and an enormous tonnage is available without great expense.

These piles form the *visible* loss, which only serve to emphasize the *invisible* loss of gases which for each ton of braize must be multiplied by 15. Fortunately, however, this condition is fully recognized by corporations prepared to remedy them.

The end of the beehive oven is in the not far distant future.

Power investigations have naturally fallen into two converging lines—generation and application, and while the lines of investigation have of course been carried on independently, the consequent result has been superimposed.

Of first importance in generation stands Combustion. When we realize the comparative volumes of raw material which enter into the complete daily problem of the large iron and steel unit, the importance of *combustion* is seen.

Take, for example, a modern by-product coke plant—the blast furnaces it will serve, the open hearth furnaces the product of *these* furnaces will supply, and the mills required to break down and finish that steel.

The totals are enormous, and as each division presents its own unique problem, it has been so studied and investigated.

The many fuels used in a modern steel structure present a wide variety of characteristics—each interesting and important—but as coal is the one big item which shows up as direct purchase, which involves the most mechanical complications due to its mining, transportation, rehandling and preparation, *coal* has been subjected to closest scrutiny.

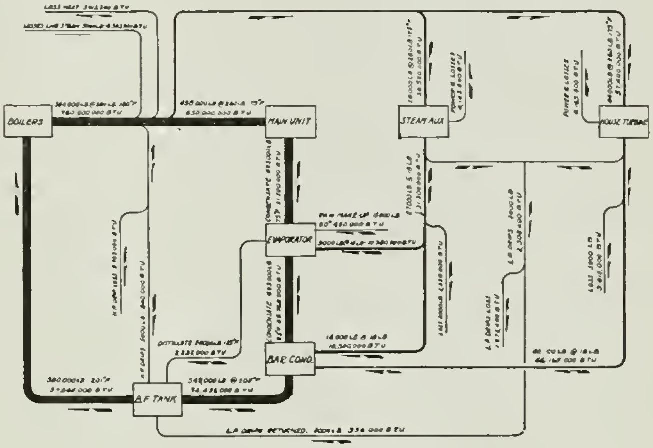


Fig. 2—Power flow graph.

The logical way to burn coal has been found to be in pulverized fuel.

If 1921 has shown any clearly defined tendency, that tendency in Combustion has centered upon *pulverized* fuel firing.

In a questionnaire by an engineering society as to topics of interest for discussion, pulverized coal was found to be the greatest in demand.

This widespread interest in the subject has been reflected in a large number of scattered installations—not great in total development, but each a nucleus around which interest centers, and expansion will take place as soon as the art is more firmly foundationed.

In particular, pulverized firing under boilers has expanded with the installation of many very successful plants, from a number of which accurate data is now available.

No detailed discussion is here necessary, as great publicity has attended a number of these plants. Much controversy is natural around a subject of such importance in which powerful forces are at work, but the elements of preference toward pulverized firing are so evident that it remains only to reconcile costs both of installation and of operation with known costs of other methods.

It is unlikely that the engineering profession will fail in the development of such an ideal.

Stokers have reached their peak—the reversion to the chain grate type, merely modified and expanded to meet forced draft, over-rating conditions, proves this. But the limitations of available grate surface are a vital consideration, and the necessity of a continuous supply of constant variety coal, classified as to size, is always present.

A paragraph from the annual report of the Prime Movers Committee of the National Electric Light Association is significant:

"While the application of the chain grate and underfeed type of stoker to high rates of combustion has seemingly been successfully accomplished, there are many indications that the art of burning coal economically is still in the process of development and that we cannot foretell at this time what methods may be used in the future. This must be particularly emphasized in view of recent installations and experiments which have been made for the purpose of utilizing pulverized fuels and by-product gases. New plants should be designed with this in mind, and special care exercised as to provision for modification and changes in such installations for future development."

Oil and tar firing present nothing new, while the rising price and future scarcity of these fuels make their use but temporary on land.

Blast furnace gas-firing has been well standardized with types of boiler equipment and burners well developed. The controversy between "dirty gas" and "wet-washed gas" seems pretty fairly settled in favor of "dirty gas"—a number of conversion back to dirty gas having been made, with no installation of importance made on "wet-washed gas.' Dry cleaning of blast-furnace gas for boiler firing has been well developed in the largest unit installed this year, and with excellent results.

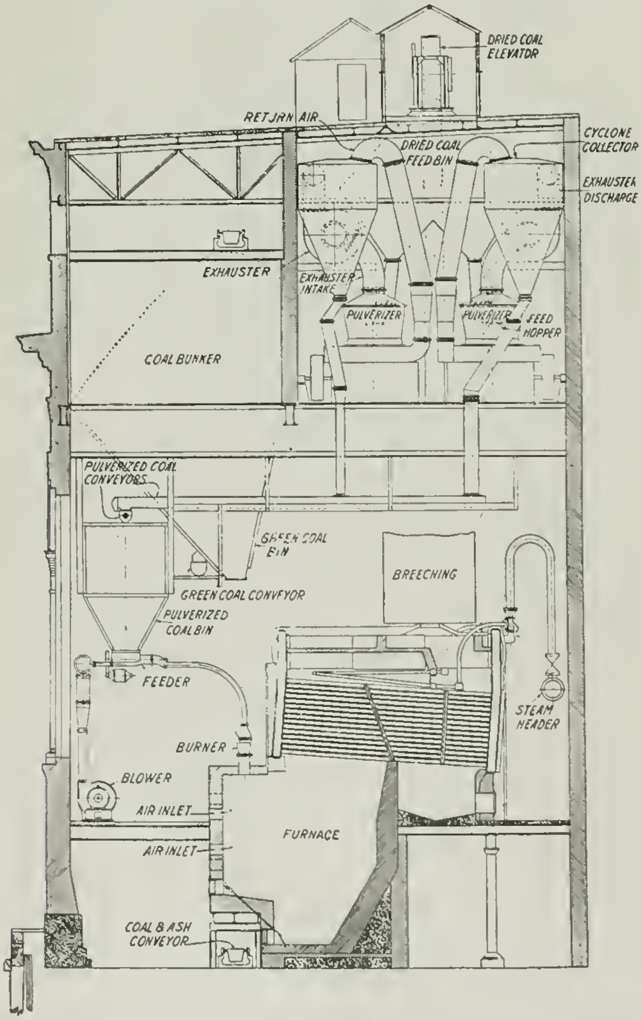


Fig. 3—Cross section through indirect firing pulverized plant.

Waste heat applications have made progress, not only on open hearth furnaces and heating furnaces, but also on duplex processes and even on gas engine wastes.

It is safe to declare that no large open hearth furnace plants will be built in the future without steam generating units included.

Nothing of importance occurred during the year 1921 in the gas-engine field. Bethlehem put into service a large gas engine unit, but no reports are yet available covering its performance.

Dr. Charles P. Steinmetz, a master mind in power development, summarizes, before the New York Electrical Society, the total situation so completely that repetition verbatim cannot be superfluous.

"The steam engine has been driven from factories and plants by the electric motor and the generator, and it will disappear from the railways of this country as soon as the railroads can finance electrification. The nation will eventually be covered with a network of transmission systems and dotted with hydraulic plants and power stations.

"In transportation the horse, the mule and the cable-car have become historical curiosities and the electric car reigns supreme. On our great trunk lines the anachronism of the steam locomotive still exists. But even the layman knows that only the unfortunate financial situation of our railroads makes the electrical propulsion impossible. It must be accomplished. The enormous consumption of coal by the railways, two-thirds of which could be avoided by electrification, must be stopped.

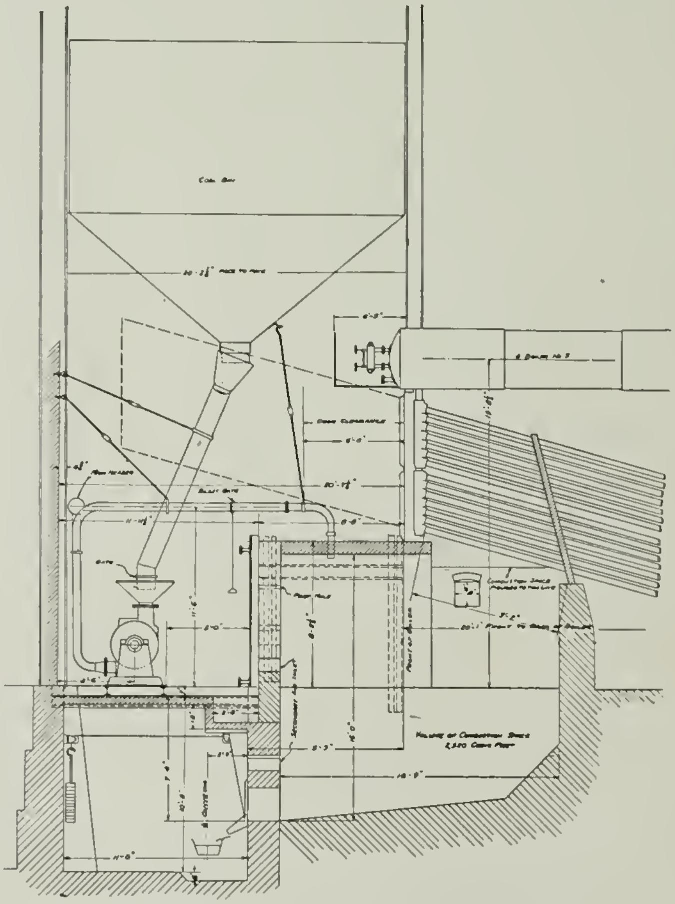


Fig. 4—Cross section through direct firing pulverized plant.

"When the first power plants were established at Niagara the question was asked whether electricity could not be sent to New York. A 100,000 hp. has been developed there, but no one asks the question any more. The reason is that the distance is so great that the electric power finds a market long before the limit of transmission has been reached. There is no economic excuse for transmission over long distances. Instead, a network of inter-connected generating and non-conducting units are springing up. It has already ignored the boundary of states, and the laws of different states are already in conflict, so that Federal supervision of power distribution will certainly be needed.

"Just as the railroads 75 years ago organized the transportation of materials, so the transmission of energy to turn our wheels and fetch and carry is being supplied by the electrical industry. Great factories which make electricity and supply it as other factories supply hats or stoves have come into being. Electrical energy is the only kind that can be easily, economically and simply conducted to the centers where it is needed, whether in small quantities for the vacuum cleaner and the house lights, or in huge masses for mills and factories. In long-distance transmission the huge voltage has crept up from 150 volts to 10, 30, 60 and finally 220,000 volts, and, experimentally, we have long gone beyond 1,000,000 volts to a voltage of 1,100,000. Just as in the past no one would have believed that possible, so in the future we may be laughed at for thinking we could not perhaps go further."

Several turbo-generator installations were completed this year, none exceptionally large, 20,000 kw. being the maximum. These at blast furnace plants where the controversy between gas engines and turbo-generator units was settled in favor of the steam conversion using surplus gas.

In the *application* of power, more progress is noted.

It is worthy of note that controlling metering, measuring and recording instruments are now considered an essential in all major power plant installations and should be an integral part of every generating unit.

A few years ago, and still in many places today, a steam gauge in the boiler room, another in the engine room and pump room were all that could be found to indicate that operations were in progress. The absence of recorders made comparisons or records impossible. To determine actual conditions, a test had to be engineered.

Regulation.

Where stoking equipment is being purchased, the question of regulation is usually disposed of by a clause in the stoker contract under the heading of "Automatic Regulation," and the only interest displayed in this subject is to find out whether the equipment is to be supplied by the purchaser or the contractor.

When the fact that the best designed and equipped plant in the country cannot be operated successfully in the absence of proper regulation is acknowledged by the engineering profession, the subject will be given the careful analysis it deserves.

Automatic regulation is too generally looked upon as a means merely to maintain a relatively constant steam pressure.

If this was the only requirement, the subject could be quickly disposed of since it is an extremely simple matter to connect up a piece of apparatus that will operate on a given change of pressure to either open or close a damper or slow down or speed up the fan.

It is an altogether different problem, however, to properly co-relate the fuel feed, air supply and stack draft so as to meet the varying demand for steam and maintain maximum efficiency throughout the range of operation.

The Una-flow engine has reached a stage in its application where it is now receiving the consideration its outstanding advantages warrant.

Its great reduction in cylinder condensation, its low average water-rate over a wide range of load conditions, its adaptability to high super-heats, to condensing operation, owing to amply proportioned exhaust chamber and large exhaust port-area, make it desirable for rolling mill drives, where a widely variable load condition is found.

Several interesting installation of comparatively small size have been made, and considerations of the direct drive of a large blooming mill by Unaflow is now in the development stage. The builders who have specialized in this type engine have no hesitation in offering single-cylinder units as large as 6,000 hp. and twin-cylinder up to 12,000 hp.

Turbo-generators have been installed in many representative plants, none exceptionally large, as present steel mill loads do not warrant larger sizes at present and none of radical design. Among these may be mentioned:

Turbo-blowers have become standard practice at blast furnaces, competing on even ground with gas engine blowers, without the necessity of costly gas washers, and with higher factor of reliability.

Turbine driven pumps seem to have been preferred to reciprocating units, principally on the score of economy in space and most of the installed power units have incorporated turbine pumps to even out the heat balance.

Turbine drive for direct-firing pulverizing units have proven more satisfactory than motors, not only due to reliability and flexibility—but also due to simplicity of controls over a range of capacities.

To close a stack damper with an intense fire on the stoker simply because the steam pressure had gone up a pound or two, was decidedly bad practice and extremely hard on chain grate links, for instance.

If the stack damper and stoker speed had been regulated not from one extreme to another, but to maintain a definite relation between coal supply, air supply and steam demand, there would have been no room for complaint on the part of the stoker man and the plant operator would not have been compelled to sacrifice 10 per cent to 20 per cent efficiency in order to protect his stoking equipment from damage

Some of the biggest force draft traveling grate installations that have been made during recent years were installed without regard to regulation and maximum results were not secured until after this subject had received the proper attention and the necessary apparatus had been installed.

Powdered coal is kicking up a lot of "dust" these days and at least one boiler in America has absorbed a lot of it efficiently. If you investigate the various installations throughout the country you will find that little or no thought had been given to proper automatic regulation. In fact, it would seem that if you powder coal the amount of air required to burn it takes care of itself.

The proper application of regulation to blast furnace stoves will help silence the howl in the boiler room for "more gas."

The proper system of regulated burners in the boiler house will result in a maintained efficiency, providing other things are in good condition in excess of 80 per cent.

Today the modern power plant is a *continuous test* record—a daily heat-balance.

Metering.

Not less important than regulation, we find metering coming to be recognized as essential in plant operation. Definite quantities enter into the total problem and without a quantitative comparison, no attempt at regulation can be made.

Flows of water, feed water, condenser water, condensate, cooling water, flows of steam, air, coal, gases are now and should be covered by meter.

Incident to meters, records of their operations must be kept, and today one of the interesting points of assembly in any power house is the instrument board, where at a glance the "book-keeping" of enormous daily quantities can be seen. Each engineer has his personal idea as to arrangement and selection of a wide range of recording possibilities—but in general, a combination of flows should be selected which will approximate test data.

A review of 12 months' practice would not be complete without a slight payment upon the mentalities that have influenced that practice. Many things are taken for granted, and most of all the proceedings of the engineering societies that seem to be accepted in the same gratuitous spirit in which such work is given. But it should not pass without comment.

No year has been more replete with engineering activities and no year has seen greater interest, and more definite applicable knowledge disseminated by the societies and the leading trade journals. The proceedings of the various societies and trade journal publications have focused general executive attention, the published reports present a mine of valuable data.

Power in its various manifestations has shared largely in the total scope of engineering activities, its characteristics have been analyzed, recorded and discussed, many conclusions have been reached and further investigational activities have been stimulated.

The individual names of the contributors and the board variety of subject-titles would form a volume in themselves. Suffice it to say that the activities of 1921 bid fair to outstrip 1920 even in greater ratio.

Every discussion of power, its production, distribution and application, should be introduced by a section on *safety*, and should not be complete unless *concluded* by emphasis upon *safety* and then *more safety*.

Because power in its production involves the very factors which constitute the most serious hazards—high temperatures, high pressure, high velocities, high rotative speeds, huge masses, noxious gases, explosive dusts and dirt, high elevations, etc. These hazards result naturally in burns, scalds, fractures, amputations, asphyxiation, loss of members, sight, falls and deaths.

Power in its distribution involves the same elements plus other equally hazardous, such as electrovention, explosions, etc., while power in its application includes all the foregoing, plus additional hazards incidental to the personal equation, such as grinding wheel failures, air hammers, electric hand drills, etc., etc., too numerous to detail.

Wherever we look this high tension industrial civilization seems to point to a compounding of personal hazards.

In the face of all this it is gratifying to note that this apparently most dangerous feature of our individual organization is actually about the *lowest* in actual recorded accidents and fatalities; just because power is dangerous, it has been *recognized* as dangerous, and safeguards have anticipated the hazards.

Today *specific* codes of procedure surround the installation and operation of all power elements—it is accepted specification—to install non-return valves on all boilers, feed-water regulation, gauge-glass protectors, duplicate water lines; engine stops are as acceptable as governors, hoisting equipment is guarded, and automatically "safety-stopped;" all gears are guarded, electric switches are of the enclosed, locked type. Wherever pulverized coal is burned definite provision must be made to cover the hazards it presents, likewise blast-furnace gas.

The net result of this *recognition* of hazards has placed power in the preferred class in all safety statistics.

When you enter a power house, a safety-first sign confronts you; wherever you turn, a safety appliance interposes itself; when you leave your last impression is one of tremendous forces under marvelous control. Nowhere has safety shown greater results.

An annual review of any subject must be, at best, a mass of generalities, and in a survey of the breadth of power such is particularly the case.

But there is a point of contact wherein the subject may be made to touch the individual reader, especially if he be an operating man or an executive engineer.

An this takes the form of a New Year suggestion—*write your own annual power review.*

There is no better way to visualize *your* progress forward or backward.

Did your operation for the closing year reflect advancement?

Were your costs higher?

How much did your combustion improve as reflected in higher evaporations per pound of coal?

Did you reduce man-power by the substitution of automatic devices?

Are you familiar with progress elsewhere?

What experiments did you enter into, and were they successful as applied to your problem?

What fundamental principles did you discover or utilize?

What magazine articles interested you or influenced you?

What engineering society proceedings interested you?

These and a hundred questions may be made a matter of valuable record, both for yourself, your successors and your company.

It is quite remarkable how valuable written facts may become, especially as a sure means of comparison—without which small progress is made.

The essence of an entire operation may be summarized upon a single comparison sheet and your personal analysis of the results of the year will be well worth filing.

In conclusion, as a summation of the possibilities of heat-balances, waste recoveries, super-power, etc., should we look into the far distant future, we might see a picture something like this:

All coal now mined along the Monongahela and Allegheny basins, now loaded in cars and hauled upon congested railways already overtaxed to handle produced material, and raw material tonnages, with various transshipments, reloading and haulages—all this coal assembled at two central points, say Clairton and Colfax.

At these points it would be elevated by tremendous grab-buckets, capacity of 1,000 tons per hour (20 cars); there coked, and all by-products recovered, gas generated to maintain present dwindling natural gas supplies, the sulphates for fertilizers, the benzols for automobile power.

The coke braize, now wasted, would be pulverized, the ash precipitated out by a process similar to the Trent and mixed with tar already recovered.

In this condition we have an ideal colloidal fuel (all recovered as by-product), which can be pumped through pipe-lines to the various points of consumption.

Such fuel presents no problems of combustion, as it is ideal for high temperatures and high ratings.

The ash having been eliminated at the central preparation plants, we have no ash handling problem, no ash and dirt, with consequent wear and tear, cost of shipment now necessary upon cars, where coal is burned (?) as at present.

The installation cost of such a plant layout will be well within the recoverable values.

Sloss-Sheffield Steel and Iron Company's Steam Generating Stations

Descriptive Article of the Modern Steam Generating Plants of This Company Located at North Birmingham, Alabama—Mine Power Plant Also Discussed.

By M. M. ARGO and H. MAULSHAGEN*

A DESCRIPTION of the latest and perhaps one of the most efficient steam generating stations in the southern district in connection with the production of iron and steel is the boiler plant and generating station of the Sloss-Sheffield Steel & Iron Company at their by-product coke oven plant, located in North Birmingham, Ala.

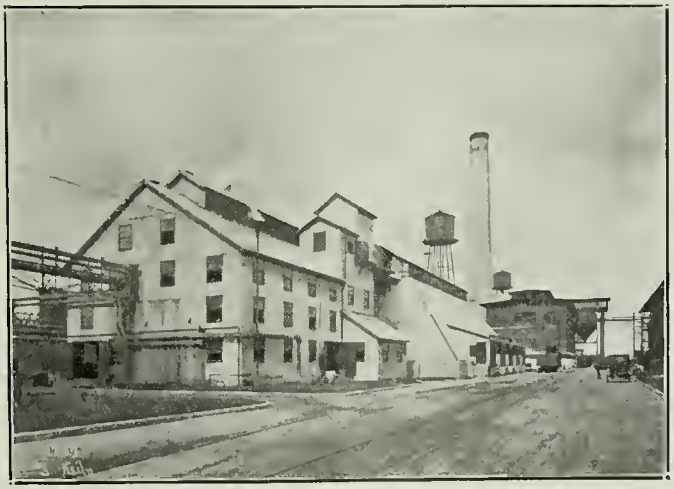


Fig. 1—View showing sulphate building of by-product plant. Boiler plant beyond railroad car. Concrete stack of boiler house plant can be seen.

Fig. 1 is view of outside of boiler house, showing location of ash hopper on right over tracks where ashes are discharged from bottom directly into railway cars.

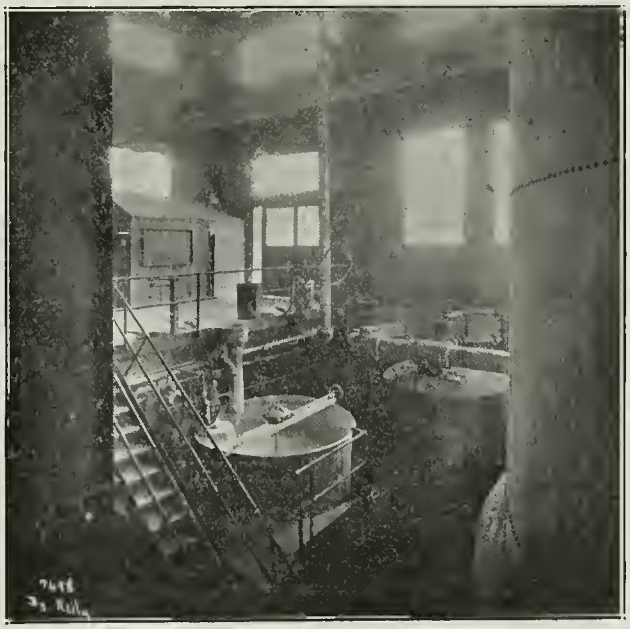


Fig. 3—View showing purification plant, mixing tank, filters and sedementation tank.

The ashes are discharged into the hopper by the Peck Carrier System, manufactured by Jeffrey Manufacturing Company. The Peck Carrier System also elevates the coal, which is discharged into a hopper under railway tracks beneath the ash bin and fed into the buckets by motor operated shakers. The trips above are set so as to discharge the coal, coke breeze or ash into their respective bins. This system is operated by a 30-hp. Westinghouse 440-volt 60-cycle induction motor and has a capacity of 150 tons per hour.

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*Mr. Argo is power engineer and Mr. Maulshagen is assistant power engineer of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala.

Fig. 2 gives a front view of the eight boilers.

These boilers were manufactured by the Babcock & Wilcox Manufacturing Company and have 6.032 square feet of heating surface each, and are rated at 603 hp., or a total of 3.618 hp. One hp. equals 34½ lbs. H_2O evaporated from and at 212 deg. F. per hour. The three steam drums are 43 in. by 13 ft. 10 in., and mud drum 48 in. by 12 ft. 7⅝ in. There are 462 3¼-in. diameter tubes. All boilers are equipped with Babcock & Wilcox patented superheaters, which have the following rating:

100 per cent	150 deg. S. H.
150 per cent	168 deg. S. H.
200 per cent	185 deg. S. H.

The boilers at present are operated at 200-lb. steam pressure 150 per cent rating and an average of 170 deg. S. H. is obtained. Each boiler is equipped with Diamond Power Specialty Company's soot blowers and all except the stoker fired boilers are equipped with Engineering Company's balance draft regulator. They have a combined space of 1,600 cu. ft. and four are equipped to burn gas only, two gas or coal, and two are stoker fired.

The gas and hand fired boilers have the Deitrick fire box of the Dutch oven type with non-water cooled arch. The stoker fired boilers have the Deitrick arch, fan-shaped arch and water cooled top.

The four gas fired boilers are equipped with eight Burkholtz Terbeck gas burners which are designed to supply sufficient gas to operate the boilers at 200 per cent rating. The four top burners are controlled by 8-in. Mason regulator, which was redesigned at this plant for this special duty; four are set by hand for normal load and regular operated valves taking care of variations.

As seen by the photograph above it was necessary to supply additional secondary air to the burners, which was done by cutting out the brick around the top of the burners in the front of the fire box; the admission of this air is also controlled by the Mason regulator operating the gas supply to the burners. The gas as burned has heat content of 570 Btu.

Flue gas analysis on gas fired boiler is as follows:

130 per cent rating of boiler	CO_2	8%
	O_2	5%
	CO	0

Stack temperature 570 deg. F.

150 per cent rating	CO_2	7.2%
	O_2	4.7%
	CO	0

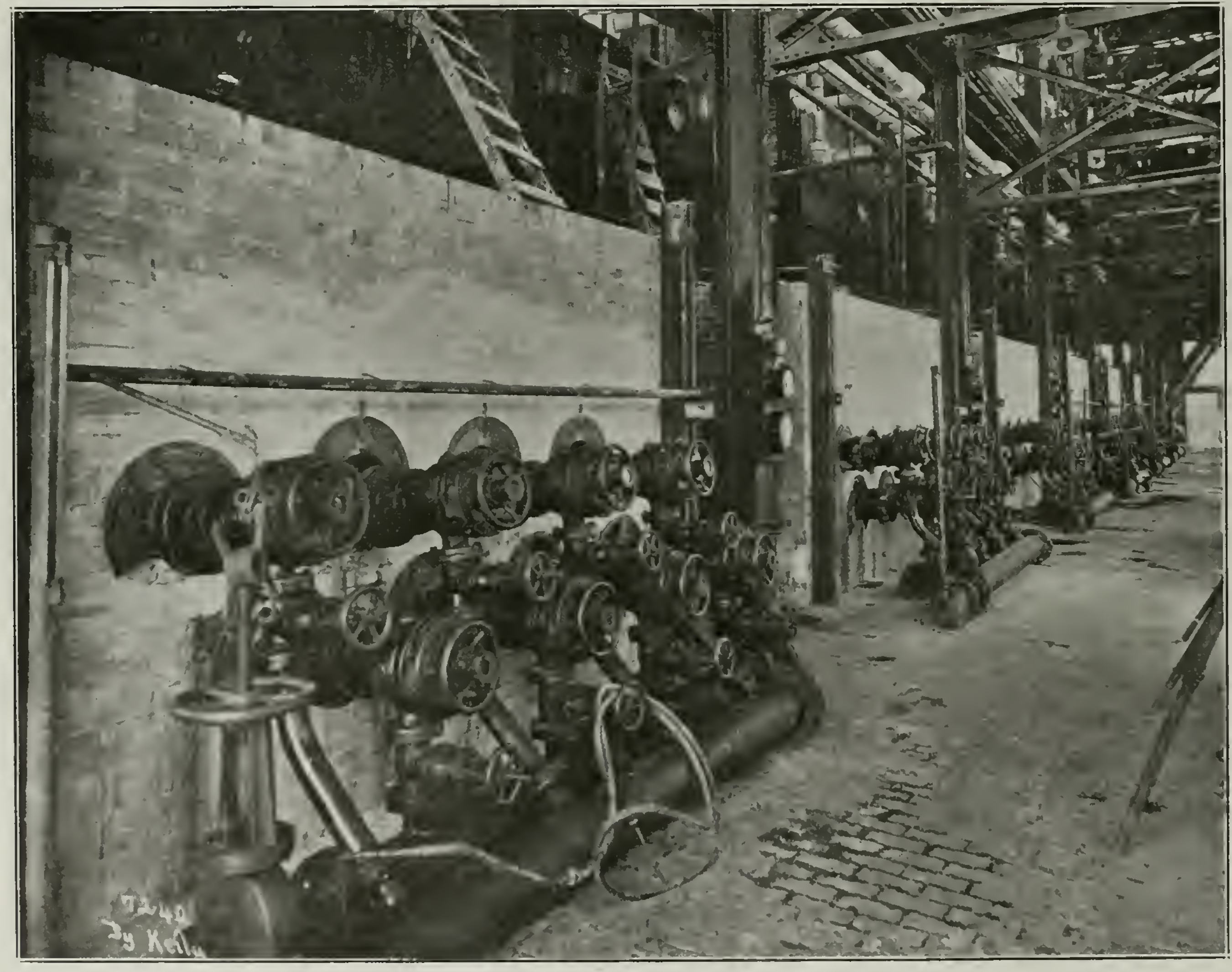


Fig. 3—Front view of the eight boilers.

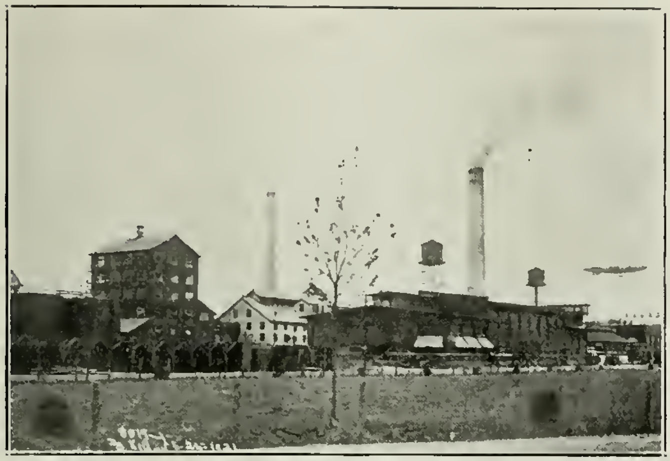


Fig. 4—View of the by-product plant showing boiler plant and power house at the right.

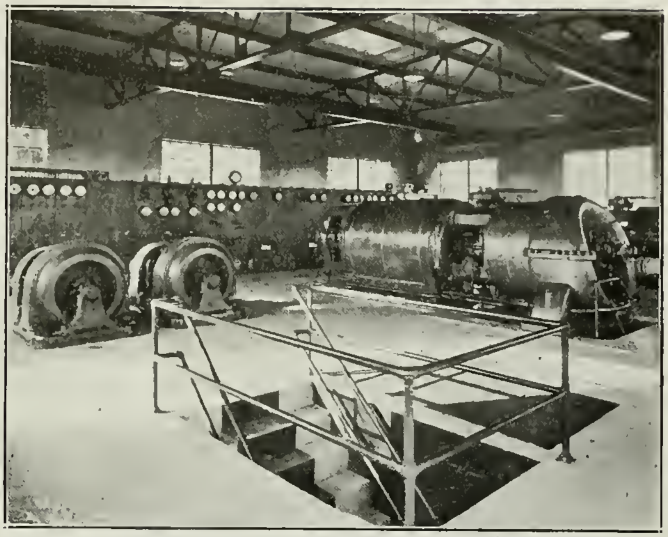


Fig. 5—Interior view of by-product power house, showing two 2,000-kw. turbo-generators and two 150-kw. motor generators.

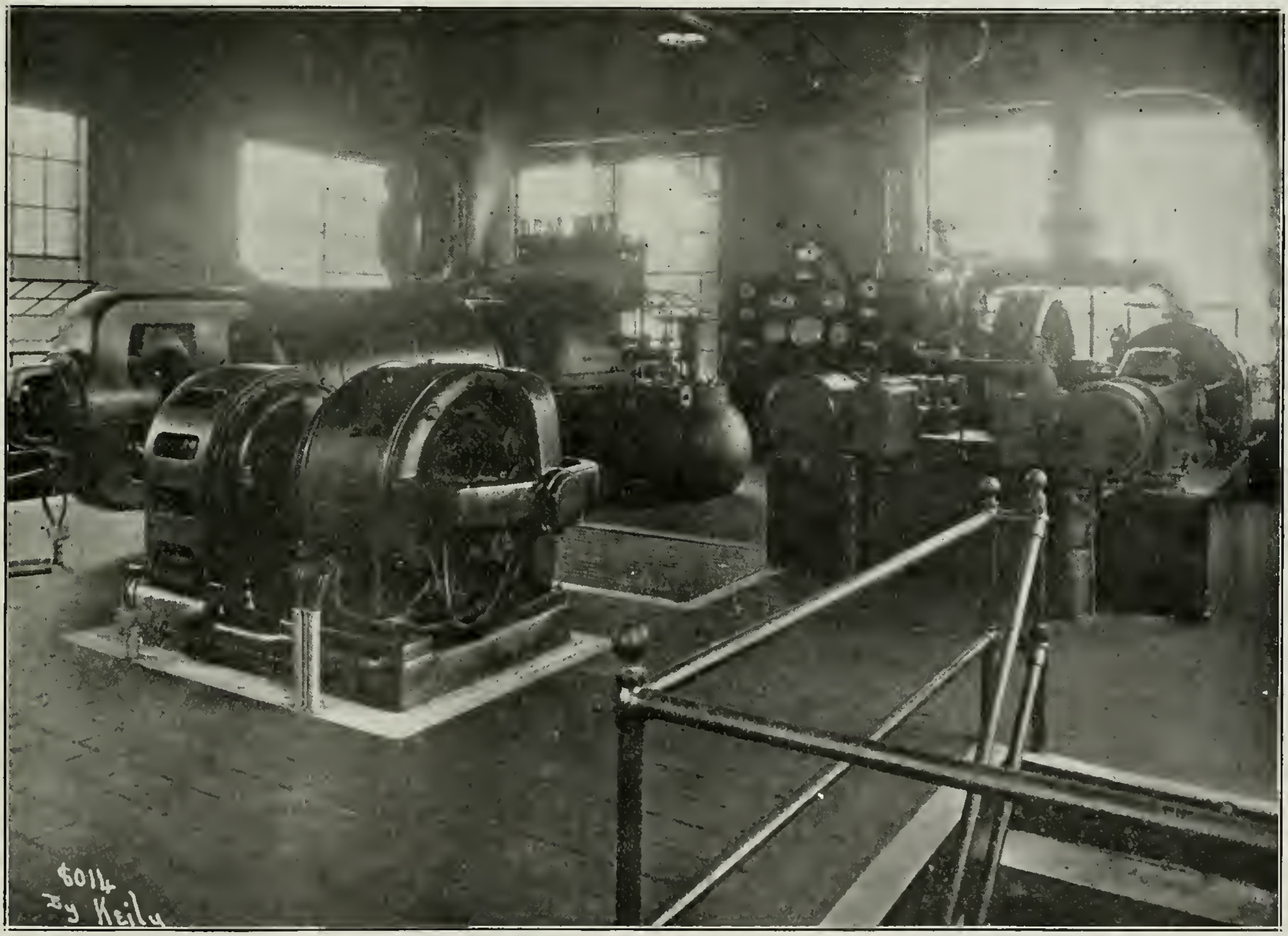


Fig. 6—Interior view of furnace power house showing gage board, 2,000-kw. mixed pressure turbo-generator 3 phase 60 cycle 6,600 volts. Ingersoll-Rand vacuum pump. 100-kw. motor generator 2,200 volts, 3 phase, 60 cycle 250 volts d.c.

Stack temperature 580 deg. F.
170 per cent rating CO_2 8%
O_2 5.4%
CO .9%
Stack temperature 600 deg. F.

The boilers are equipped with five gas burners each and also have stationary grates for hand firing, which permit hand firing when the gas supply is low due to increased demand by City of Birmingham. The City of Birmingham obtains its gas supply from the by-product plant, where the boiler plant and central power plant of the company are located. The boiler plant only utilizes the surplus gas which is not needed by the city.

The stoker fired boilers are equipped with Combustion Engineering Company's chain grate stokers of the Coxé type, capable of burning coke breeze or coal, coke breeze being burned at the present time. Each grate is operated by a 25-hp. 250-volt d.c. variable speed motor, through suitable reduction gears, giving a grate speed of from 10 to 20 feet per hour. Forced draft is supplied by a Siroco blower, driven by a 100-hp. Waite turbine. A similar blower driven by a 100 motor is used as a spare.

Considerable difficulty was experienced at first in burning breeze with the Coxé stokers, and a careful study was made to determine the cause of the trouble. The ignition arch was changed from a water cooled arch at 45 deg. to a fan shaped ignition arch of the Deitrick type. With a few other minor changes, the stokers can now be driven at 225 per cent rating with ease.

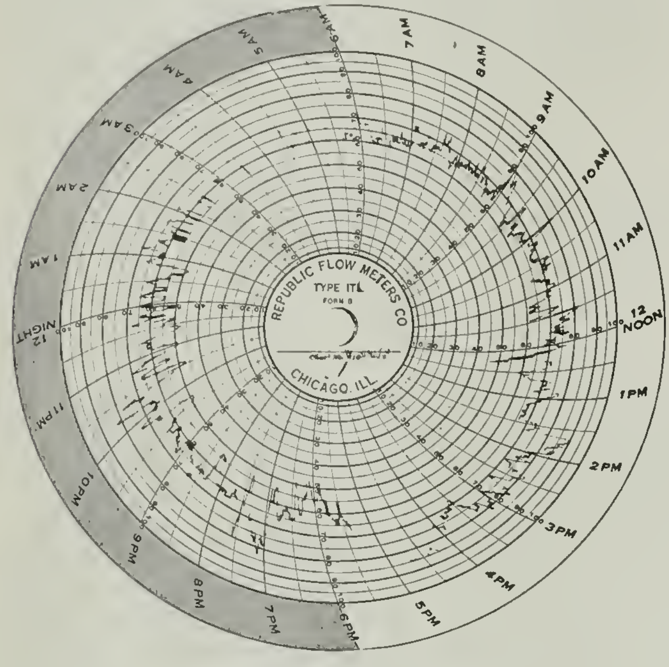


Chart 1—Showing varying output of gas fired boilers controlled by regulator.

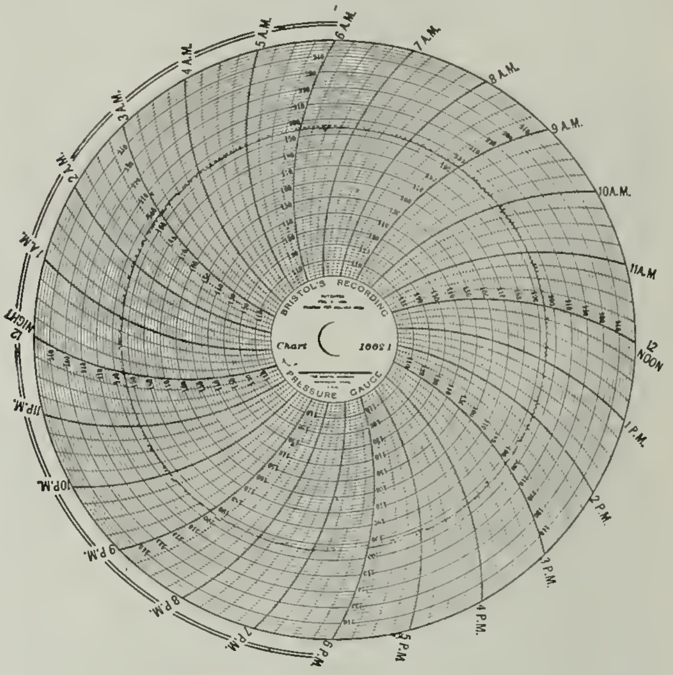


Chart 2—Chart from recording steam pressure gage showing small variation in pressure controlled by the Mason regulator.

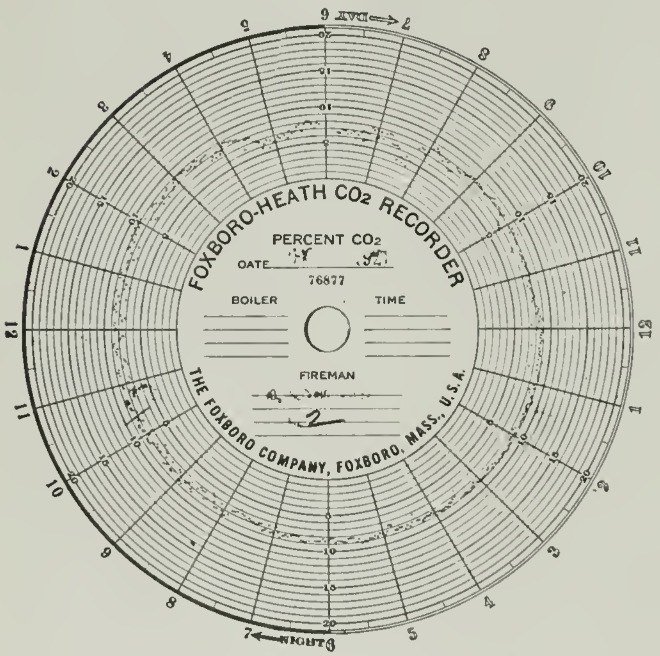


Chart 3—CO_2 gas fired boiler showing slight variation due to gas regulator action.

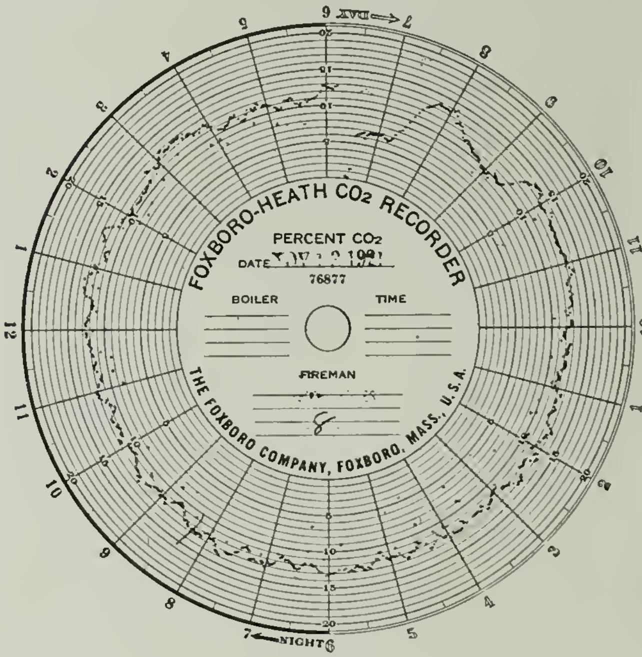


Chart 4—CO_2 chart on chain grate stoker boiler burning 22 Lr coke breeze.

Feed Water System.

The feed water system consists of three 500-gallon centrifugal pumps operating at 275-lb. pressure each. Two are turbine driven and one is motor driven. Feed water pressure is controlled by a Copes automatic feed valve and diaphragm governor handling a differential between the steam pressure and the water pressure of 30 to 40 lbs. The boiler feed water is treated by the Sorge-Cochran hot process water softener, consisting of chemical tank, sedementation tank, and three sandfilters.

Chemicals used are lime and soda ash.

The fundamental principle of this treatment is that lime and soda ash in the correct proportion mixed with the raw feed water in the heater and in the sedimentation chamber at a temperature above 205 deg. will completely react within 10 minutes and precipitate all scale forming salts in the sedimentation chamber, which are removed by blowing off the sludge at the bottom of the sedimentation tank. The suspended matter will be removed as the water passes through the filters, leaving the sedimentation tank on the way to the boiler feed pump. The soluble salts then pass over to the boiler and constitute the total solids, or the concentration of the water in the boiler. The concentration is lowered or total solids removed by blowing the boilers at regular intervals for a specified time, which is determined by the test of the water taken from each boiler.

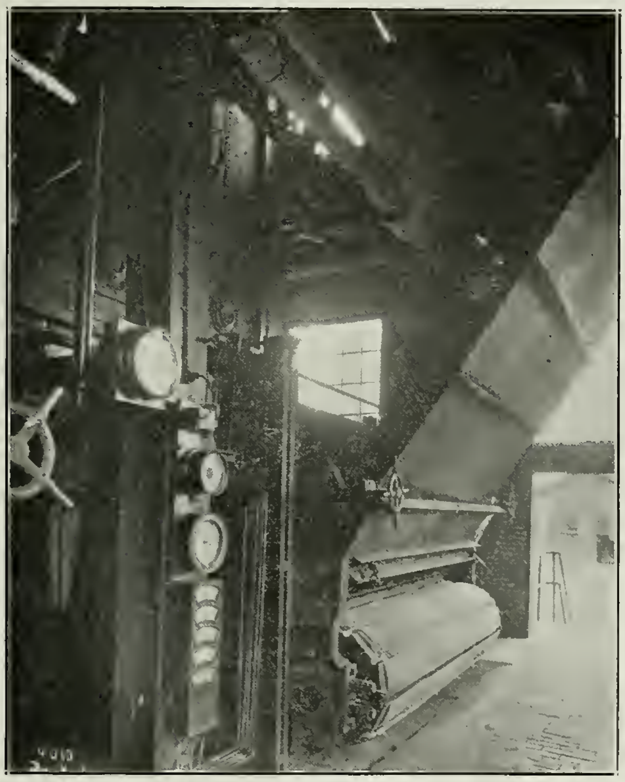


Fig. 7—Combustion Engineering Company chain grate stoker. Also shows record thermometer, Bristol recorders, Republic instruments and steam flow charts and precision instruments.

The air in the water is removed in the open-type heater on the top of the sedimentation tank. Live and exhaust steam is used to heat the feed water and the raw feed water as applied has a hardness of 14 grains per gallon. By treating this with six pounds of soda ash and 9.5 pounds of lime per each 1,000 gallons of water, which is the correct treatment at present, to total hardness of soap solution, test is reduced to 2½ grains per gallon, with the total solids averaging 7 grains per gallon. The boilers begin to show signs of priming at 250 grains. Concentration, therefore, is kept below 150 grains per gallon by blowing down the boilers at intervals of 1.5 hours for 80 seconds per boiler. The length of the interval and time of blowing is governed entirely by the load on the boiler, blowing longer and more frequently as the load increases. The alkalinity of the boiler is kept above 20 grains per gallon and below 30 grains per gallon. If the water becomes neutral of acid, scale forms, so that 20 grains per gallon is used as a safe margin to work upon. If it goes above 30 grains per gallon, it deposits a lime coating on the interior of the boiler.

The test on the treated water is made with Ph and Mo as indicators and NA_2O H_2SO_4 as reagent. The Ph indicates all hydroodsand one-half carbonate, and the Mo the other hand of the carbonates. The theoretically correct treatment is 1. Ph and 2.4 Mo. A test is made of the treated water every two hours, and of the boiler water for alkalinity and concentration once each day. All tests are recorded and filed. The concentration is found by determining the grains of sodium chloride per gallon with $AgNO_3$ as reagent, and multiplying the ratio of the NaCl to the total solids which is a definite factor. The capacity of the water softener is 5,000 lbs. per hour.

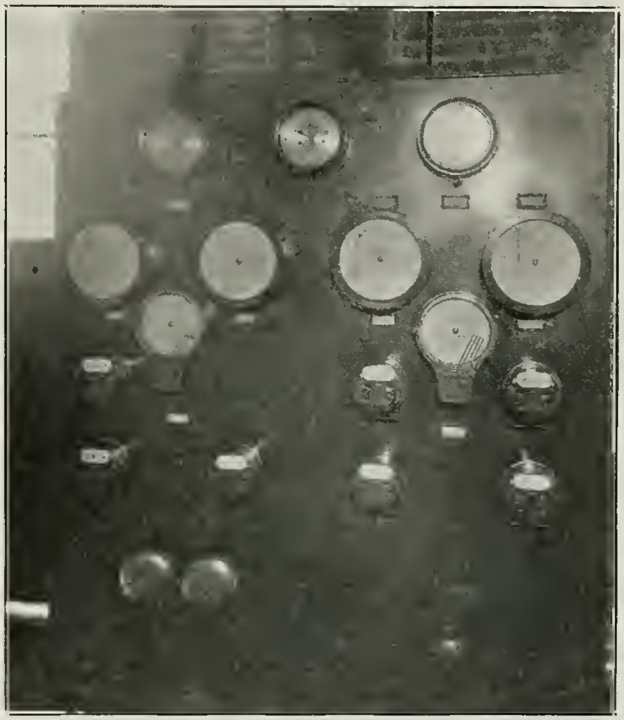


Fig. 8—Gage board in boiler house showing, top row, left and right: Steam pressure and boiler feed water pressure gage. Second row: Recording steam pressure gage, feed water pressure, steam temperature in header, gas pressure. Third row: Boiler blow off recorders. Fourth and fifth rows: Integrating steam flow meters, one for each boiler.

One very noticeable feature of this plant is the accuracy of the records. Every pound of feed water or material is either weighed or measured that enters the plant. All steam leaving the plant is measured. Accurate records are kept from day to day as to the operating cost. The efficiency of the plant is very high, considering the slow operation, and the fact that the boilers are carrying only a slight overload; the efficiency is held approximately at 70 to 75 per cent. If conditions were such that the steam was needed, the daily efficiency would possibly be much higher. The Deitrick fantail ignition arches have proven very satisfactory for burning coke breeze from the ovens which has been coked 35 hours. The majority of the plants have been unable to burn the breeze without mixing coal with it, where it has been coked over 22 hours.

By-Product Power House.

Included in the equipment of the power house are two 2,000-kw. 6,600-volt, 3-phase, 60-cycle, 80 per cent power factors generators driven by two 2,000-kw. condensing turbines, operating at 3,600 rpm. and 200-lb. steam pressure. The turbines and generators are direct connected. Mounted on the same shaft as the generators are 125-volt exciters. The two turbines exhaust into the Elliott-Erhart jet condenser. The air from the condensers is extracted by ejectors. The water is pumped from the condenser by an Elliott-Erhart centrifugal pump, driven by a Terry steam turbine. The switchboard was manufactured by the Westinghouse Electric & Manufacturing Company and consists of 25 panels, controlling 6,600-volt circuits to the generators, mines, by-product plant, etc. The switchboard has recording and integrating meters, maximum demand meters for determining the load on the different circuits besides the regular meter equipment usually found at the switchboard.

Fig. 9—Spray ponds. Two at left are power house used with jet condensers, others are used in cooling mill water recirculated through mill system after cooling. Sprays reduce temperature 3-4° below atmosphere.

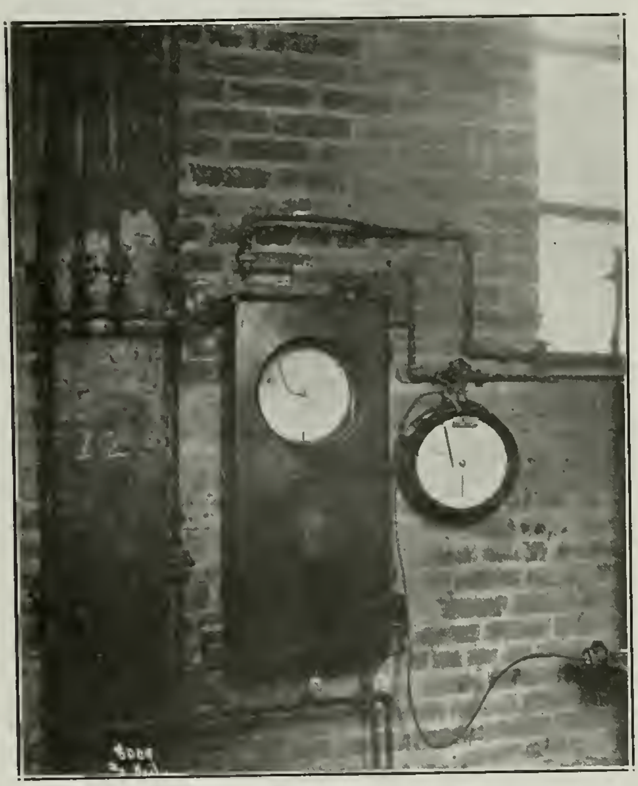


Fig. 10—Flue gas stack thermometer CO_2 recorder.

North Birmingham Plant.

An additional power plant, located at the North Birmingham furnace of the Sloss-Sheffield Steel & Iron Company, and the idea in locating a unit here was to utilize low pressure steam exhausted from the furnace by blowing engines. This plant, as well as the one located at the by-product plant, was designed by Martin J. Lide, consulting engineer and mechanical engineer of the company, and the construction was carried on under his guidance by Mr. T. B. Dryer, construction engineer.

The furnace plant at the present time consists of one 2,000-kw., 3-phase, 60-cycle, 6,600-volt G. E. turbo-alternator. This turbine is a mixed pressure machine, taking the exhaust steam when the blowing engines are operating and automatically changing to high pressure steam at 125-lb. gauge pressure when the exhaust steam is not available. This machine is very rugged and capable of handling a heavy overload without injury. One of the interesting parts of the plant is the condenser, which was designed by Martin J. Lide, and is the largest condenser of the barometric type in the Birmingham district, requiring 8,000 gallons injection water a minute. High vacuum is maintained, giving a high over all efficiency of the plant. A water rate of 32 pounds is averaged, which is considered very good for a mixed pressure machine. The other equipment in the plant consists of an Ingersoll-Rand vacuum pump, two Midwest circulating pumps, one motor and one turbine driven of 7,500 gallons capacity each against a 42-ft. head. The switchboard and motors were furnished by the Westinghouse Electric & Manufacturing Company. The steam flow motors were furnished by the Republic Flow Meters Company. The plant receives an average of 1,250-kw. from low pressure steam with one blast furnace operating.

Distribution.

Between the two plants there is a double 6,600-volt tie in line, capable of delivering 3,000 kw. at either end in case either plant is shut down. Feeders leave each plant to the furnaces, by-product plant, coal mines and rock quarry. The voltage is stepped up to 44,000 and is transmitted to the several coal mines 18 miles distant. Current for the by-product plant is stepped down to 440 volts. The transmission line to the ore mines, near Bessemer, 15 miles distant, has not yet been completed.

Mine Power Plant.

This plant is being built as a standby plant in case of interruption to the service or to the lines due to transmission line trouble. The plant consists of two 750-kw., 3-phase, 60-cycle, 2,300-volt turbo-generators made by the Allis-Chalmers Manufacturing Company. The turbines have been thoroughly repaired and are capable of handling a large overload. Suitable transformers tie this plant into the power system. The boiler plant consists of four Sterling boilers rated at 361-hp. each, 150-lb. gauge pressure, and are equipped with Diamond soot blowers.

NEW POWER MAP OF PENNSYLVANIA.

A map of Pennsylvania showing the location of the power stations and electric transmission lines used by public utility companies has just been published by the United States Geological Survey, Department of the Interior.

This map is the second of a series now being published, that of New York having been recently issued. Two other maps are nearing completion, one covering New Hampshire and Vermont and the other covering Massachusetts, Connecticut and Rhode Island, and maps of Maine, New Jersey, Maryland and Delaware are also in preparation. These maps were prepared in collaboration with the power companies.

The Influence of Gas Cleaning on Plant Economy

Comparison of Dry Cleaning vs. Wet Washing of Raw Gas—Dry Cleaning Will Prove Advantageous in Every Case of Combustion of Blast Furnace Gas, With the Exception of Its Use in Engines.

By WALTER N. FLANAGAN
Steam Engineer, Ohio Works, Carnegie Steel Company

BLAST furnace gas is one of the nicest fuels to handle if properly taken care of and one of the meanest fuels if the equipment is not carefully considered. It is only in very recent years that the above remark could be made. Formerly the gas was considered difficult to handle, difficult to burn efficiently and caused endless trouble with dust. All of these troubles have been greatly reduced and in fact practically eliminated in some installations. On account of the low heating value and large volumes produced, large pipes and valves are required. Since the gas is poisonous the valves must be tight and only goggle valves are now considered. To eliminate the necessity of a large crew of men working for hours up in the air in a gas laden atmosphere to open and close a valve, a type of goggle valve has been developed and put into successful operation which can be operated from the ground in two minutes by two men. Properly designed burners eliminate combustion troubles. Dust troubles can be eliminated by cleaning the gas.

However in most installations equipment is used which only partly cleans the gas and delivers it saturated with moisture that precipitates out in the lines carrying dust along which eventually causes clogging. For stove and boiler operation the absolute cleaning of blast furnace gas would be too expensive. One quarter of a grain per cubic foot is now the accepted value of cleanliness for wet washed gas to insure freedom from dust troubles in stoves and boilers. The latest developments have shown that up to one-half grain per cubic foot is just as satisfactory if hot, dry cleaned gas is used.

The heat contained in blast furnace gas consists of the calorific value and the sensible heat or heat due to temperature. When the gas is cleaned in contact with water the temperature is reduced, usually to the temperature of the water, thus the sensible heat is lost in an effort to eliminate dust troubles.

The analysis of many samples of blast furnace gas showed an average of:

CO_2	13.50%
O_2	.11%
CH_4	.22%
H_2	3.72%
CO	25.20%
N_2	57.25%

This gives a lower calorific value of about 93.4 Btu per cu. ft. of dry gas at standard conditions.

Fig. 1 shows the heat loss per cu. ft. of gas by washing, for various initial gas temperatures. The washed gas is assumed to be cooled to 62 deg. F. which is the average final temperature in most plants where a satisfactory cleaning is obtained, and to have a moisture content of 6.3 gr. per cubic foot which is slightly less than saturation at that temperature. The raw gas is assumed to contain 35 grains of moisture per cu. ft. which represents average conditions.

Fig. 2 shows the monetary value of the sensible heat loss, based upon $4.00 coal while Fig. 3 shows the relation of the net sensible heat value to the total value of blast furnace gas. In all of the above figures the heat saved is the difference between the heat required to raise washed gas and that required to raise hot gas to the same stack temperature.

The loss due to cooling blast furnace gas may be calculated for any condition as follows. Since the specific heat of gases at high temperatures is not constant the curves of Fig. 5 are included to furnish a means, accurate enough for all practical purposes, of calculating the sensible heat of blast furnace gas and the heat loss due to cooling the gas.

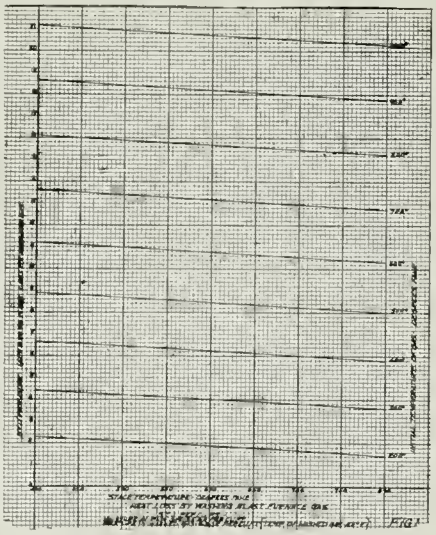


Fig. 1.

The density of water vapor is approximately .04767 lb. per cu. ft. and the volume of water vapor per cu. ft. of gas can be readily calculated if the moisture content in grains per cu. ft. is known.

From the analysis and moisture content of the gas and the curves of figure 5 the tabulation may be made as follows:

Gas analysis................Given below.
Moisture in raw gas.........35 grains per cu. ft.
Temperature of raw gas.....400 deg. F.
Moisture in washed gas......6.3 grains per cu. ft.
Temperature of washed gas..62 deg. F.
Stack temperature..........600 deg. F.

Vol. of moisture in raw gas—

$$\frac{35}{7000} \div .04767 = .1049 \text{ cu. ft.}$$

Vol. of moisture in washed gas—

$$\frac{6.3}{7000} \div .04767 = .0189 \text{ cu. ft.}$$

Constituent.	Fraction per cu. ft. of dry Fce. Gas.	Heat cu. ft. from 62–400° Btu.	Heat, cu. ft. from 62–600° Btu.	Heat, cu. ft. from 400° to 600° Btu.	Total Heat from 400–600° Hot Gas Btu.	Total Heat from Washed Gas Btu.
CO_2	.1350	8.5	14.0	5.5	.743	1.890
O_2	.0011	6.2	10.0	3.8	.004	.0011
CH_4	.0022	8.6	14.3	5.7	.013	.032
H_2	.0372	6.2	10.0	3.8	.141	.372
CO	.2520	6.2	10.0	3.8	.957	2.520
N_2	.5725	6.2	10.0	3.8	2.175	5.725
H_2O (Hot Gas)	.1049	7.3	12.1	4.8	.503	...
H_2O (Washed Gas)	.0189	..	12.1	..	...	.229
Totals					4.536	10.779
Less Heat required for hot gas						4.536
Available sensible heat, or heat loss by washing, per cu. ft.						6.243

The value of blast furnace gas or of the sensible heat content may be calculated as follows on heat value basis:

$$\text{Dollars per furnace per year} = \frac{(\text{Ave. cu. ft. per min.}) \times (\text{Btu per cu. ft.}) \times 1440 \times 365}{2240 \times (\text{Btu per pound of coal})} \times (\text{Dollars per ton of coal})$$

From a 500-ton furnace there is at least a net flow of 50,000 cu. ft. of gas per minute. This is the basis of the curves of Figures 1 to 4.

In any plant where coal has to be burned continuously to supply power the actual value of the gas is higher than shown on a heat value basis since usually less equipment and labor is required than for coal to maintain a given efficiency.

The value of the sensible heat of blast furnace gas is shown in Figure 2. The average furnace in the United States has an average top temperature of about 400 deg. F. This means an annual value of at least $22,000 per furnace based upon $4.00 coal or an annual loss of $22,000 per furnace where the gas is cooled in washing.

In an effort to save this loss many plants burn the gas, at least in the boilers without cleaning. This results in greater boiler capacity from the same amount of gas, but requires more labor blowing tubes and removing dust from the settings, and also loses more flue dust. Used in stoves it precludes any possibility of small checkers or high efficiency stoves and loses about $2,000 per furnace per year cleaning and heating up stoves. Mr. A. N. Diehl in a paper before the American Institute of Mining Engineers estimated the total saving of clean gas in stoves to be $.1591 per ton of iron produced or about $30,000 per year for a 500-ton furnace. This is due to increased production, increased stove capacity and decreased limestone consumption. While there is $22,000 worth of heat saved each year per furnace there is more than $22,000 worth of flue dust, labor and efficiency lost. With high top temperatures encountered in some furnaces in which the flue dust is discarded it may pay to burn raw gas. However, flue dust is now considered valuable in many plants and is charged into the furnaces either raw or treated.

Just recently raw gas from the dust catcher had to be used as a temporary expedient on stoves in a plant in the Pittsburgh District and it was found that the hot blast temperature was 200 deg. F. higher than when using wet washed gas. Of course as the checkers filled with dust this temperature would drop. If the gas was dry cleaned, retaining the sensible heat and at the same time furnishing clean gas to the stoves, this increase in temperature could be maintained throughout the furnace campaign.

If the gas is dry cleaned the sensible heat is retained, more flue dust is recovered than with wet washing, due to elimination of sump loss, there is a saving in power as the dry cleaning requires about one-fiftieth of the power for wet washing, less labor is required, there are no sumps to clean, boiler efficiency is higher

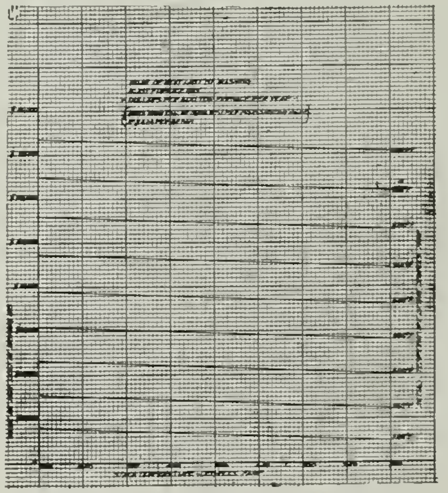


Fig. 2.

due to more rapid and more thorough combustion, higher initial temperature and the absorption of more heat by radiation. Since combustion is more rapid with hot gas, combustion chambers can be made smaller than necessary for burning cold gas with a given burner. This means lower first cost for buildings and settings. Some flue dust contains a relatively high amount of potash and with wet washing it is next to impossible to recover the potash content unless all of the wash water is evaporated. If the dust is caught dry, however it is commercially profitable to recover the potash content as relatively small amounts of wash water have to be evaporated.

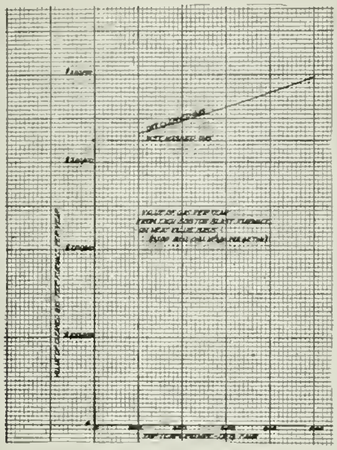


Fig. 3.

The gas mains and burners in a dry cleaned gas installation after two years of operation were found to be entirely free from dust deposit. This feature alone is enough to cause serious consideration of dry cleaning possibilities, as with wet washed gas sludge deposits in lines and burners until it interferes with operation. This deposit must be removed at fairly frequent intervals and the removal usually interferes with the regular operation.

It has been often suggested that the moisture content of raw or dry cleaned gas, which must be raised to stack temperature upon combustion, more than offsets the value of the sensible heat. The slight slope of the curves in Figure 2 shows in actual dollars and cents the effect of this moisture. In washing gas unless the temperature of the gas is dropped below 112 deg. F. on an average no moisture is precipitated in the washer. The more moisture eliminated the greater is the sensible heat loss in the other constituents of the gas. Tests have shown that in wet washers unless the gas temperature is dropped below the dew point, the moisture content is actually increased due to the absorption of moisture from the wash water in contact with the hot gas.

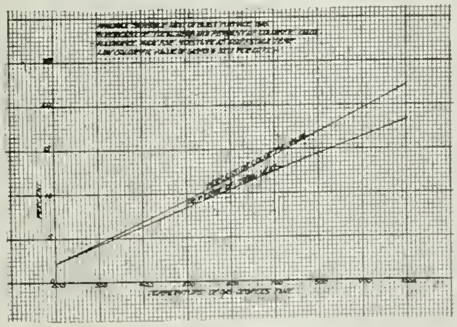


Fig. 4.

Since the average top temperature is about 400 deg. F. and stack temperatures in good stove and boiler practice seldom exceed 550 deg. F. the moisture in the dry gas has to be raised only 150 deg. F. and becomes a negligible quantity.

In addition to the financial return by dry cleaning blast furnace gas there is also the standpoint of the communities in which furnace plants are located and which are supplied by our rivers. Where raw gas is used in addition to the loss out of stacks the flue dust is a nuisance to the surrounding community. The water from the wet washer sumps adds to the chemical and mechanical pollution of the streams by carrying away dissolved salts and iron ore which from a conservation standpoint should be charged into the furnaces. With more stringent smoke and sewage disposal laws the time is approaching when these practices will be prohibited. In locations where water is scarce or the cost of pumping high the dry cleaning process eliminates a serious problem.

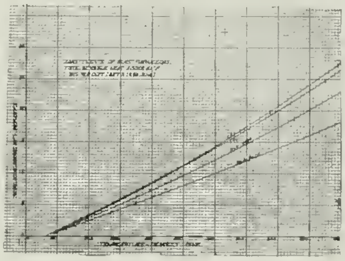


Fig. 5.

Since gas is such an advantageous fuel, requiring less labor and cheaper equipment, and permitting higher combustion efficiency than with solid fuels, efforts should be made to obtain the utmost from it and to eliminate the burning of coal.

The following is an itemized comparison showing the savings by dry cleaned gas over washed gas and over raw gas per year for a 500-ton furnace:

Comparison of Dry Cleaning vs. Wet Washing or Raw Gas. Saving Per 500-Ton Blast Furnace Per Year.

	Saving Per Year Dry Cleaned Gas Over Washed Gas.	Saving Per Year Dry Cleaned Gas Over Raw Gas.
Saving of Sensible Heat (See Fig. 2) (400 deg. F. Gas—550 deg. F. Stack Temperature)	$22,000.00	
Fuel Saving Due to Increased Efficiency (5 per cent better eff. from tests of dry vs. wet cleaned gas) (Eff. with rough gas same as with wet—capacity greater)	15,000.00	$15,000.00
Saving of $.1591 per ton of iron-cleaned gas over rough		30,000.00
Value of additional flue dust recovered by dry cleaning @ $3.00 per ton (47,500 lbs. per day from dry cleaner) (40,300 lbs. per day from wet cleaner) (15,000 lbs. per day from stoves and boilers with raw gas)	3,400.00	13,050.00
Saving in power (75 kw for Wet Washer—1.5 kw for dry cleaner @ $.01 per kwh)	6,400.00	
Difference in cost of removing flue dust from wet washer sumps and from dry cleaner to stockpile	2,500.00	
Saving in blowing tubes (Tubes blown twice a week when using dry cleaned gas)	800.00	1,900.00

Removing dust from settings (Difference between cleaned and raw gas).		1,600.00
Fuel lost heating stoves after cleaning.		900.00
Labor cleaning gas mains and stoves.. (Does not include value of gas wasted or bled during cleaning mains or loss due to increase in top pressure during period of partial line stoppage)	500.00	3,300.00
	$50,600.00	$65,750.00
Operating labor and repairs—Dry Gas Cleaner less Wet Washer..........	1,000.00	1,350.00
Net Total Saving................	$49,600.00	$64,400.00

Based on coal @ $4.00 per gr. ton; Labor at 30c per hour.

Above figures are based upon wet cleaned gas of approximately ¼ grain dust per cu. ft. and dry cleaned dust of ½ grain per cu. ft.

One-half grain per cu. ft. is not the limit of dry cleaning as blast furnace gas can be dry cleaned to a given dust content with an installation costing about the same as a wet washing installation for the same cleanliness.

In conclusion it might be said that since the heat saving is only about 30 per cent of the total saving over wet washing, that dry cleaning will prove advantageous in every case of combustion of blast furnace gas with the exception of its use in engines. A dry cleaning plant to reduce the dust content to gas engine requirements would be fairly elaborate and the hot gas would reduce the power of the engines due to the low filling factor of the hot gas, . e. small weight of gas per stroke. Here the wet primary process in connection with the Theisen washers or equivalent is the only method to be considered unless superchargers are employed. Even with superchargers the power for compressing hot gas to an equivalent weight of cold gas is greater than the power obtained from the sensible heat.

New Flue Gas Filtering System

EVERY boiler operator familiar with CO_2 equipment knows that the first requisite for successful operation is cleanliness and complaint is sometimes heard of the time required for blowing out the gas sampling lines and keeping the mechanism in clean condition. Realizing this situation, the Uehling Instrument Company, 71 Broadway, New York City, have been experimenting with many substances to perfect means for completely excluding soot and dirt from the gas sampling line.

Finally a material combining the necessary porosity and refractory qualities was found and this is now embodied in the new Uehling "Pyroporus" filter, which is placed on the inlet end of the gas sampling line inserted in the flue or last pass of the boiler furnace. This filter consists of a heavy but highly porous disc held in a cup shaped casting by means of a bolt. It is not injured by very high temperatures.

Formerly the gas was withdrawn through an open-ended pipe and the filtering was accomplished with cotton waste; this necessitated more or less blowing out of the gas line and required frequent renewal of the filtering material. With the new arrangement, the soot builds up the "Pyroporus" filter and does not appear to enter the pores to any extent, in fact, many of these filters have been in service for months without ever having been blown out or replaced and without apparently offering appreciable increased resistance to the gas flow.

It is not yet known what life may be expected of these filters, but present indications are that they will last for several years without any attention whatsoever. They are, however, inexpensive, and are easily replaced. To facilitate inspection and replacement the manufacturer has also developed a frame to be inserted in the brickwork and a holder for the sampling pipe which is quickly fastened in place by two bolts. By loosening the nuts on these two bolts and by unscrewing the union at the bottom of the section of sampling line, it requires but a moment to withdraw the filter through the frame. The frame is the width of two bricks, hence it is a simple matter to insert it in the setting without cutting a large hole in the brickwork. When the sampling line is to be inserted through a metal casing, as with a horizontal tubular boiler, the frame is omitted and the holder is bolted directly to the metal casing of the boiler.

Aside from the great gains in the reduction of attention required on the part of the attendant by the improved arrangement, another very important advantage results, namely, that a smaller pipe line can be employed because its entire cross sectional area is effective when it is kept clean. Smaller pipe is not only easier and more economical to install, but of even greater advantage, it takes less time to draw a given volume of gas through it and consequently the CO_2 recorder reflects furnace operating conditions more promptly when smaller pipe is used.

While designed primarily for Uehling CO_2 equipment, "Pyroporus" filters may be used for other makes of instruments and the frames and holders are useful in connection with pyrometers, draft gauges and for providing convenient openings in the furnace for test and observation purposes.

COKE AS A FUEL.

Floyd Parsons, editor of Gas Age-Record and well-known writer on industrial economics, urges the use of coke as a fuel, he says:

"I am convinced that in the future gas will be manufactured entirely from bituminous coal and that eventually all of the coke will be utilized in the process. In such a practice a ton of coal should produce about 42,000 cu. ft. of 375 Btu gas having a specific gravity of about 55. Gas appliances will be constructed and adjusted to use this grade of gas efficiently.

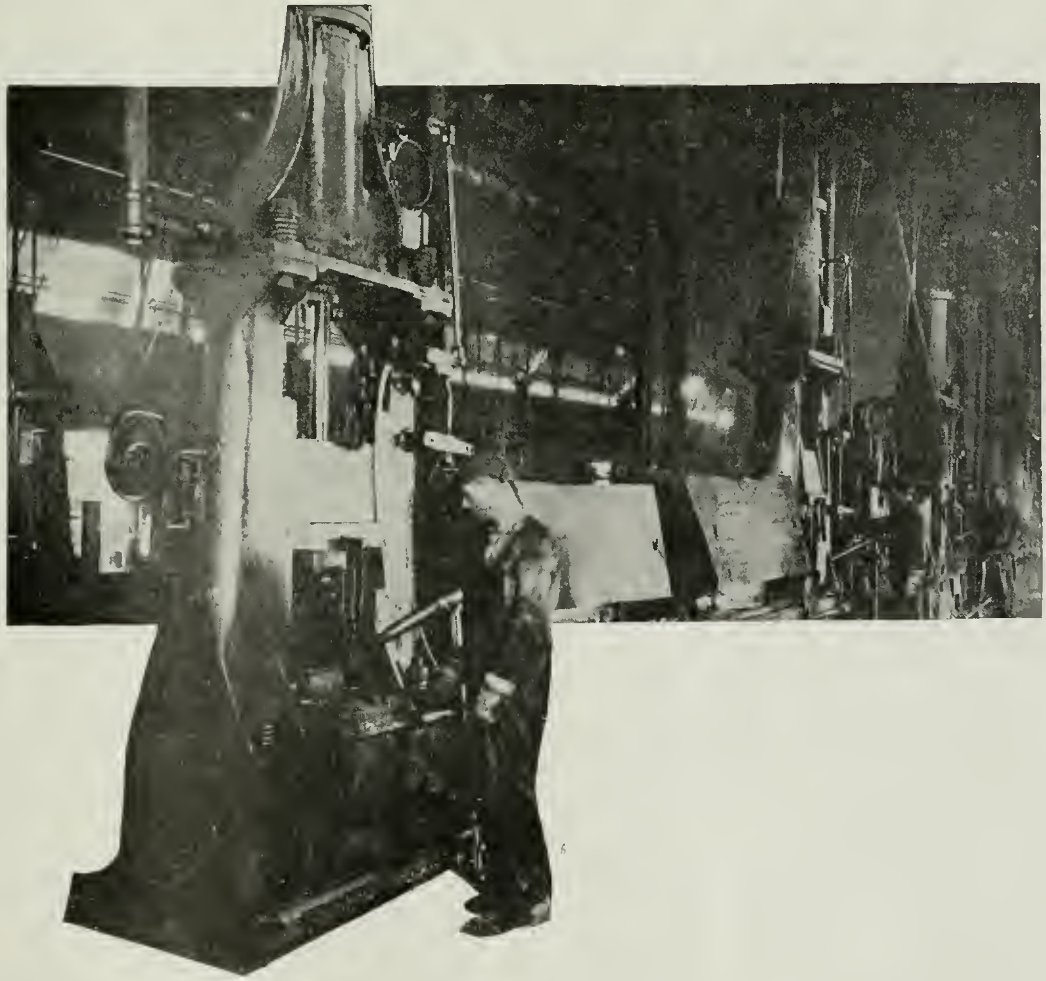
"Heat values can be carried in the form of gas a long distance through a metal pipe more economically than they can be carried in the form of electricity the same distance through the medium of a metal wire or cable. Electricity has a monopoly in the field of energy for power. Gas has an equal opportunity to monopolize the field of energy for heat."

Forging and Heat-Treating Department

Heating Furnaces for Forgings
By C. FISCHER

Effect of Sulphur and Oxides in Ordnance Steel
By WILLIAM J. PRIESTLEY

Refractories in the Steel Plant
By W. A. HULL



Heating Furnaces For Forgings

The Utilization of Waste Gases from Heating Furnaces—Results Obtained Very Surprising When Waste Gases Are Used by Preheating the Steel Direct.

By C. FISCHER
Superintendent Light, Heat and Power, Mesta Machine Co.

THERE are still a number of heating furnaces, using natural gas as a fuel, in operation, which will have to be rearranged sooner or later for the use of a different kind of fuel. The price of natural gas is steadily rising, whilst the output is on the decline, so much so, that one of the large utility companies in Pittsburgh has found it necessary to mix artificial gas with their natural gas in order to take care of the demand.

It seems therefore quite in order that the gas companies distributing and supplying natural gas should start and lead campaigns advocating the conservation of that fuel and educating consumers in the efficient and economic use of the gas.

The results obtained with the various types of forge heating furnaces as to the amount of gas consumed per weight of steel heated vary within wide limits, which fact can be attributed to the different furnace designs and the varying operating conditions in existence.

All furnaces, irrespective of the type and the kind of fuel used, require oxygen for the combustion of the fuel. The oxygen is taken from the air, which is supplied to the mixing apparatus or burner either at atmospheric pressure or by means of fans above atmospheric pressure. The object of the mixer or burner is to thoroughly mix the fuel with the oxygen in the air, admitting only that amount of air, which is necessary for the proper combustion, no more nor less. Too much air carries heat away and not enough air reduces the heat production. The burners obtainable carry out this duty with a varying degree of efficiency, but with a burner properly designed and selected so as to suit the furnace and operating conditions good results can be obtained.

The waste gases leaving the furnaces at high temperatures contain a considerable amount of heat, which in some cases is lost entirely, in other cases is made use of under waste heat boilers, and still in other cases is employed for preheating the air necessary for the combustion.

It is the third application of the waste gases which has been adopted extensively in forge heating and other industrial furnaces, as each furnace with its air preheating chambers becomes a self-contained unit. There is no doubt, that the fuel consumption per weight of steel heated can be reduced by adopting this class of furnace, but whether the total heating costs are very much lower than with the ordinary type heating furnace is not so certain. The first capital outlay and the maintenance of these furnaces with checker chambers are high, the operation has to be skillfully performed, and furthermore it is a difficult matter to thoroughly mix air preheated to a high degree with the gas, unless further complications in the form of movable burners or mixers are introduced.

It occurred to the writer, that the waste gases could be advantageously put to use by preheating the steel direct, and the results obtained with three furnaces so arranged proved that a step in the right direction was made.

The mean specific heat of steel for various temperatures is approximately as shown in curve below.

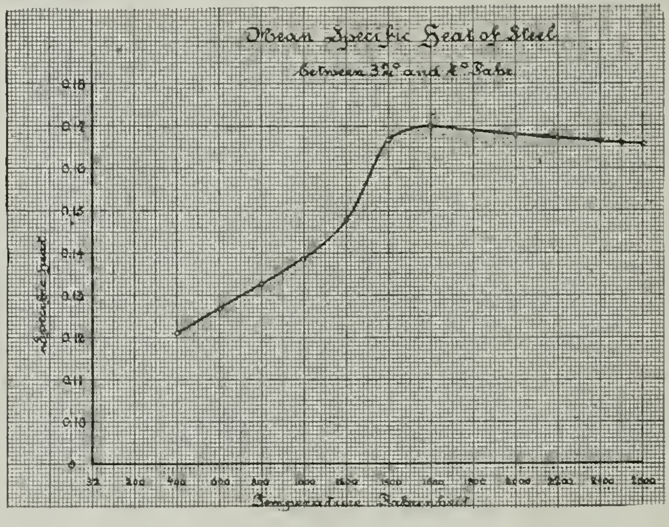


Fig. 1.

The forging temperature is around 2400 deg. F. The mean specific heat of steel between 32 deg. and 2400 deg. F. is about 0.167, therefore the amount of heat required to raise the temperature of one pound of steel to forging heat is:

$$0.167 \times 2400 = 400.8 \text{ Btu.}$$

The actual heat consumed is considerably more and may vary from 1500 to 6500 Btu, according to the type of furnace, fuel and mixing device used. For every pound of steel heated, the heat lost amounts to 1100 to 6100 Btu, this means in dollars and cents:

Fuel.	Cost per Million Btu.	Cost of Heat Lost Per Ton of Steel Heated.
Natural gas	$0.50	$1.10 to $6.10
Manufactured gas	$0.26 to $0.42	$0.52 to $5.12
Fuel oil	$0.43	$0.95 to $5.25

While it is possible during a test to attain low heat consumption figures, it is also a fact that test conditions hardly exist over long periods of ordinary operating conditions. During the ordinary operation of a forge shop there occur unavoidable delays which increase the heat consumption and furthermore not every pound of steel heated is forged.

The construction of a double door furnace separated by a wall and connected by means of a flue as shown in Fig. 2 and Fig. 3 is a sketch of two large single door furnaces connected together. Each side or furnace is equipped with a Maxon Premix Burner. This burner consists of a fan driven by a constant speed motor, both gas and air inlets are on the suction side and the volumes are controlled by a simple valve for the gas and a disk shutter for the air. By this means the mixture is always under control and it is possible to obtain and maintain any desirable mixture. The delivery pressure of the mixture is constant, thus being able to keep the furnace under a slight pressure and so prevent infiltration of cold air.

Owing to the circular construction of the furnace the flame has a rotating motion, thus obtaining the longest possible travel of the gases. This feature makes the furnace especially adaptable for heating ingots. A further advantage of this design is the low maintenance cost, no roofs falling in, no checker chambers to burn out, and the doors or frames need not be water cooled. Not only is the simplicity of design of both furnace and burner an outstanding feature, but all complicated operating devices, which may cause delays and breakdowns, thus interferring with the economy and reliability, are practically excluded. Very often special refinements are included in an installation to increase the economy, which, when considered with the installation as a whole, materially increase the risk of delays and shutdowns.

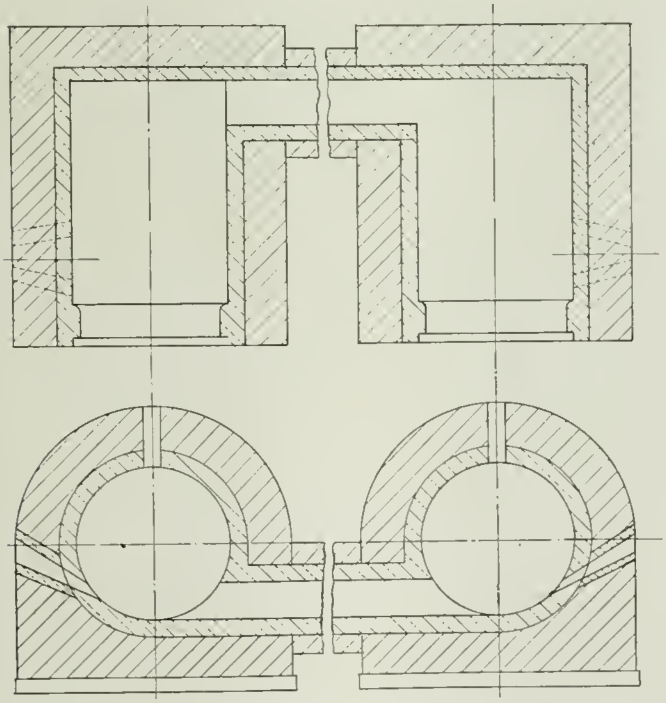


Fig. 2—Two single door forge furnaces for reheating ingots and half finished forgings. The waste gases of either furnace can be used for preheating purposes.

Both sides or furnaces can be charged and the waste gases of either one can be used to preheat the charge in the other. As soon as the finished heat is drawn, the side or furnace containing the preheated material can be brought up to temperature. By closing the damper each side or furnace can be operated independently.

The temperature of the material can be brought up gradually until the critical point is reached, which is between 1200 deg to 1500 deg. Fahr., when the heating can go on more rapidly. Owing to the easy control with which the admitted air can be handled, the surfaces of the steel do not oxidize so readily and the material loss due to this cause can be reduced to a minimum.

The gas consumed, using natural gas as fuel, during the heating period of an ingot of which 45,000 lbs. were heated amounted to 82,500 cu. ft., being 1.83 cu. ft. or about 1830 Btu per lb. of steel heated.

On the basis of the weights of forgings as they leave the forge shop the average amount of gas consumed over a period of one week was 3.5 cu. ft. or about 3500 Btu per lb. of steel forged. The minimum and maximum gas consumption during that period were 2.85 and 4.9 cu. ft. per lb. respectively. The heating and forging operations however were not continuous and the average amounts of gas consumptions mentioned include the gas lost owing to delays. In a forge shop where delays are kept at a minimum and the operation is continuous as in normal times, the heat consumption of 3500 Btu per lb. of steel forged can not only be maintained, but can be reduced with equipment as above described. The heating furnaces have to be of such sizes and construction as to suit the dimensions of the unshaped material, to heat small pieces in large furnaces or vice versa reflects on the efficiency of the furnace.

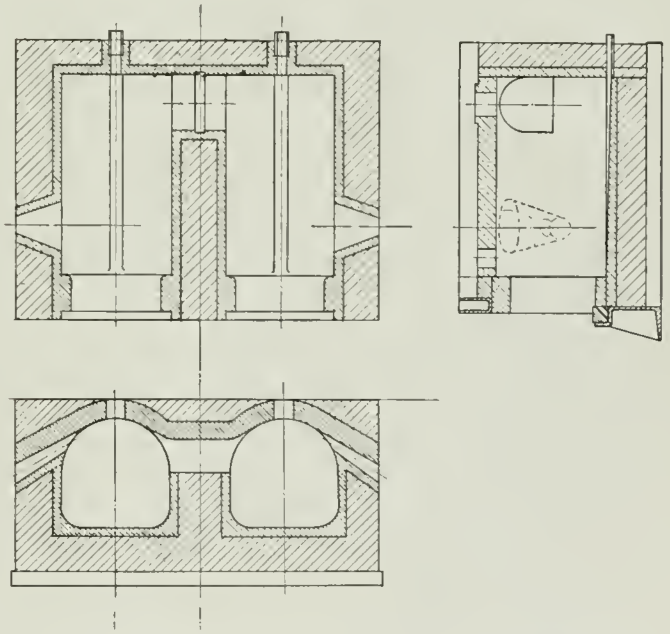


Fig. 3—One double door forge furnace for reheating ingots and half finished forgings. Either side of furnace can be used independently or waste gases of one side can be used for preheating material in other side.

Effect of Sulphur and Oxides in Ordnance Steel

Describing the Manufacture and Treatment of Steel at the Naval Ordnance Plant, South Charleston, W. Va.—Design of Gun Forgings.

By WILLIAM J. PRIESTLEY

IN THE manufacture of gun forgings and other steel parts that, in service, are subject to sudden high stresses and shocks, it is most desirable to use steel possessing the greatest toughness and ductility possible without sacrifice of strength. In order to obtain this condition, it is necessary to procure steel that shows the highest possible elongation and reduction of area without lowering the tensile strength and elastic limit. Proper heat treatment of the steel can control this condition within certain limits. When heat treatment has failed to produce the desired results, metallurgists have used steels containing molybdenum, zirconium, vanadium, chromium, tungsten, etc.

The purpose of this paper is to describe a method by which these desired physical properties may be procured — by the elimination of certain impurities that inherently exist in steel made by the open-hearth process, and without the use of expensive alloys.

Design of Gun Forgings.

In the manufacture of gun forgings, a certain elastic limit is fixed by the designer, and the walls of the gun are made of the proper thickness, allowing a suitable factor of safety for the high stresses and sudden shocks that occur during gun firing. The elastic strength of the gun is about 1.4 times the stress set up at any point along the bore of the gun during firing with the maximum powder charge.

As the stresses set up in the walls of the gun during firing are mostly "tangential," all physical tests are taken in this direction. Due to the length of the forgings, these tangential test bars are always taken at right angles and transverse to the direction of flow of the metal in forging. Furthermore, test bars taken across the grain of the metal will more frequently expose defects and foreign inclusions in the steel than will bars taken in the direction of flow of the metal in forging. Impurities in the steel will also be more readily detected by transverse † test bars.

With a fixed tensile strength and elastic limit, a steel with higher elongation and reduction of area is more desirable for service where sudden stresses and great shocks are encountered. The high elongation denotes ductility and the high reduction of area denotes toughness; for the purposes just mentioned, these properties are preferable to a higher tensile strength and higher elastic limit with a lower elongation and lower reduction of area.

The manufacture of ordnance forgings from electric steel is not an innovation. It was tried, during the war, in a number of plants. Some of these plants were not as successful as others, probably because the managers were not sufficiently experienced in the many other phases of manufacture necessary in the making of ordnance forgings.

Steel made in an electric furnace will not be of the best quality unless all operations and reactions are performed completely and satisfactorily. Electric steel with its greater freedom from oxides and non-metallic impurities is more uniform, more homogeneous, and more dense than ordinary open-hearth steel, and if it is cast at too high a temperature or chilled beyond a certain point in the mold, incipient cracks will develop. These minute cracks are radial and are most frequently found near the center of the ingot or forging. Numerous electric-steel plants working on ordnance material, during the war, were troubled with these defects, which from their physical appearance in test bars were called "snow flakes."

A diversity of opinion has always existed between the leading ordnance steel plants regarding the method of teeming steel into the molds. Some have consistently adhered to bottom pouring while others have claimed better results from top pouring direct, or through funnels or boxes. The method apparently makes little difference if the steel is placed in the mold at the proper temperature and has been properly cleansed before teeming. Top pouring direct obviates the danger of getting runner brick into the ingot, which frequently occurs in the case of bottom pouring. It also obviates the danger of sand washing into the molds with the metal from the funnel or box. Bottom pouring will give a better surface on the ingot and for some purposes may be more desirable.

Results Obtained with Electric Steel.

Some interesting results were obtained recently in the manufacture of heavy ordnance forgings at the U. S. Naval Ordnance Plant, South Charleston, W. Va. The steel was made by the duplexing process, in which cold charges of pig iron and scrap were melted in a 75-ton basic open-hearth furnace, where the dephosphorizing was done, and subsequently the deoxidizing and desulphurizing was done in two 40-ton basic-lined electric furnaces. A comparison of the physical results obtained from forgings made by this process with similar forgings made directly in an acid open-hearth furnace at the works of one of the leading industrial steel plants, noted for high-grade open-hearth steel, shows that the steel with the lower phosphorus and sulphur has the greater toughness and ductility Transverse tensile test bars from electric steel, though having the same tensile strength and elastic limit as the bars from the open-hearth steel, have a much greater elongation and reduction of area.

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*Abstract of paper to be presented before American Institute of Mining and Metallurgical Engineers, New York, February 20-23, 1922.

†Tensile test bars referred to here as transverse are taken from the forging in such a manner that their axis is at right angles to the direction of flow of the metal in forging. In the specifications for gun forgings, bars of this kind are referred to as "tangential." The axis of a "longitudinal" test bar is parallel to the direction of flow of the metal in forging.

The results given in Tables 1 and 2 were obtained on tangential tensile test bars. All forgings received a green annealing before machining; after machining they were quenched and drawn. For the results given in Table 2, it was impossible to procure comparative results from open-hearth or electric steel made in private industrial plants. The first impression on comparing these results is that the higher elongation and reduction of area are due to the low phosphorus and sulphur, as shown by the chemical analysis; all the other elements are approximately alike.

Effect of Phosphorus.

It would be difficult to draw any comparison between the open-hearth and electric steel in regard to the phosphorus content. This element is in solid solution with the iron as a phosphide and the percentages are too small in both the open-hearth and the electric steel to denote any difference even with a microscope. The lower phosphorus in the electric steel might have a slight effect on the elongation, due to producing a somewhat smaller grain and decreased brittleness in the steel.

Effect of Sulphur.

It has been stated by a recognized authority on the manufacture of steel that "the effect of sulphur on the cold property of steel has not been accurately determined but it is certain that it is unimportant. In common practice, the content varies from 0.2 to 0.10 per cent and, within these limits, it has no appreciable influence on the elastic ratio and the elongation or the reduction of area." This statement probably relates to commercial steels tested longitudinally. In this case the sulphur, in the form of manganese sulfide, has been drawn out into thin shreds in the direction of forging or rolling and is not so easily noticed in the results of longitudinal test bars as it would be in the case of transverse bars. With the overbalancing amount of manganese present in all the steels referred to in this article, probably no iron sulfide is present in the steel for none of the ingots showed any signs of tearing during forging. Steel containing iron sulfide is known to tear in forging and is termed "hot-short" by steelworkers. Manganese sulfide has been described as being present in the ingot in the form of small globules between the grains of the metal. Having about the same fusing point as the metal, these inclusions become equally plastic when the ingot is heated for forging and are drawn out into long, thin shreds—just as slag is drawn out in wrought iron. If, however, the amount of manganese sulfide present is not enough to form these globules, these shreds will not be developed in forging and transverse test bars will show as good results in elongation and contraction as longitudinal bars.

The following test bars were taken from a piece of this steel. Two of the bars were drilled longitudinal with the forging and the other two tangential. They were given exactly the same heat treatment, quenched at 1425 deg. F., and drawn at 1200 deg. F.; the results were as follows:

	Tensile Strength, Lb. Per Sq. In.	Elastic Limit, Lb. Per Sq. In.	Elongation, Per Cent.	Reduction of Area, Per Cent.	Fracture.
Tangential	111,500	55,500	21.3	44.5	Silky lipped.
Tangential	108,500	58,000	20.9	40.2	Irregular and woody.
Longitudinal	109,600	58,500	24.1	55.8	One-half cupped silky.
Longitudinal	109,400	59,700	24.1	56.3	Three-fourths cupped silky.

It will be noted that the tensile strength and elastic limit are practically equal in the tangential and longitudinal bars, but the non-metallic enclosures in the steel caused the tangential bars to show a lower elongation and lower contraction than the longitudinal bars.

Effect of Oxygen.

There is nothing in the usual chemical analysis to show how much oxygen is present in steel. It exists in small amounts in even the best steel and has bad results. In large amounts, it produces tearing during forging or rolling, and when cold is brittle under shock. If present in steel, it is probably in the form of iron and manganese oxide and silicates. Oxygen is most prevalent in basic open-hearth steel. Where non-metallic enclosures are great enough to analyze, they have been reported to show the following composition: SiO_2 50 per cent, MnO 30 to 40 per cent, Al_2O_3 7 to 18 per cent, FeO trace. In the acid open-hearth furnace a more effective reaction between the slag and the steel tends to deoxidize the steel more thoroughly. This cannot be done completely on account of the air present in the acid open-hearth furnace.

A condition exists in the basic electric furnace which cannot exist in the basic or the acid open-hearth furnaces. With a reducing atmosphere in the furnace, it is possible to form a calcium carbide slag free from metallic oxides; with constant rabbling of the bath, any oxides in the steel will rise to the slag, where they are reduced by the carbon present. The iron and manganese are returned to the bath, and the resulting carbon monoxide is liberated to the atmosphere of the furnace. Unless the slag and bath are free from oxygen, it would be impossible to maintain a carbide slag; and unless the slag and bath were thoroughly deoxidized, it would be impossible to retain the sulphur in the slag as calcium sulfide.

Hence, the conditions that bring about the elimination of sulphur from the steel guarantee that oxides and other non-metallic impurities have also been eliminated. This is demonstrated in the case of the last two forgings in Table 1. While the forgings were made by the electric refining process in different steel plants, the test bars of steels containing the higher sulphur, show no better results than the forgings made by the acid open-hearth process. Photomicrographs of the electric steel with high sulphur, reveals more en-

TABLE 1.

	Carbon, Per Cent.	Manganese, Per Cent.	Silicon, Per Cent.	Phosphorus, Per Cent.	Sulphur Per Cent.	Nickel, Per Cent.	Strength, Pounds Per Square Inch.	Limit, Pounds Per Square Inch.	Elongation, Per Cent.	Reduction in Area, Per Cent.
Forging, 16 in. diam. by 9 ft. long, 8½ in. bore; weight 5000 lb. Average results from 10 forgings (or 20 bars) of each class										
Open-hearth steel*	0.36	0.66	0.23	0.04	0.039	2.98	98,013	57,720	20.4	36.9
Electric steel	0.34	0.64	0.22	0.012	0.008	1.16	95,435	64,010	24.5	58.3
Physical requirements	...	...	....	....	....	...	80,000	50,000	21.0	30.0
Forging, 11 in. diam. by 28 ft. long, 7½ in. bore; weight 6000 lb. Average results from 10 forgings (or 40 bars)										
Open-hearth steel	0.37	0.65	0.21	0.040	0.044	3.02	104,785	73,162	19.6	39.4
Electric steel	0.30	0.67	0.179	0.012	0.009	2.81	96,995	67,785	24.2	55.9
Physical requirements	...	...	....	....	....	...	90,000	55,000	18.0	30.0
Forging, 9 in. diam. by 28 ft. long, 5½ in. bore; weight 4000 lb. Average results from 10 forgings (or 40 bars)										
Open-hearth steel	0.38	0.64	0.206	0.039	0.040	3.09	103,185	73,251	19.2	39.9
Electric steel	0.34	0.65	0.212	0.014	0.012	2.87	100,340	72,610	23.2	52.5
Physical requirements	...	...	....	....	....	...	90,000	55,000	18.0	30.0
Forging, 26 in. diam. by 2 ft. long, 5 in. bore; weight 4000 lb. Average results from 5 forgings (or 15 bars)										
Electric steel*	0.37	0.54	0.182	0.020	0.026	2.66	110,182	67,067	17.8	37.1
Electric steel	0.35	0.72	0.169	0.006	0.008	2.91	108,681	77,038	20.2	49.3
Physical requirements	...	...	....	....	....	...	95,000	65,000	18.0	30.0
Forging, 9 in. diam. by 28 ft. long, 5½ in. bore; weight 4000 lh. Average results from 10 forgings (or 40 bars)										
Electric steel*	0.39	0.53	0.16	0.020	0.025	2.65	95,245	64,979	19.3	37.0
Electric steel	0.34	0.64	0.21	0.014	0.012	2.87	100,340	72,610	23.2	52.5

*These ingots were made by a private industrial plant during the war.

TABLE 2.

	Carbon, Per Cent.	Manganese, Per Cent.	Silicon, Per Cent.	Phosphorus, Per Cent.	Sulphur, Per Cent.	Nickel, Per Cent.	Chromium, Per Cent.	Tensile Strength, Pounds Per Square Inch.	Elastic Limit, Pounds Per Square Inch.	Elongation, Per Cent.	Reduction in Area Per Cent.
Forging, 17½ in. diam. by 28 ft. long, 10 in. bore; weight 12,000 lb. Average results of 10 forgings (or 40 bars)											
	0.36	0.72	0.224	0.014	0.009	2.90	...	98,225	67,777	25.0	55.3
Physical requirements								90,000	60,000	18.0	30.0
Forging, 22 in. diam. by 11 ft. long, 16 in. bore; weight 6000 lb. Average results of 10 forgings (or 60 bars)											
	0.35	0.74	0.184	0.012	0.009	0.59	...	99,856	63,953	23.9	55.6
Physical requirements								93,000	53,000	18.0	30.0
Forging, 22½ in. diam. by 11 ft. long, 17 in bore; weight 6000 lb. Average results of 10 forgings (or 40 bars)											
	0.36	0.55	0.206	0.021	0.015	3.14	1.39	140,332	124,182	17.1	48.0
Physical requirements								130,000	105,000	15.0	40.0
Forging, 24 in. diam. by 8 ft. long, 16 in. bore; weight 6500 lb. Average results of 10 forgings (or 20 bars)											
	0.35	0.75	0.214	0.012	0.008	0.52	...	100,195	64,875	24.0	53.9
Physical requirements								93,000	53,000	18.0	30.0
Forging, 32 in. diam. by 2 ft. long, 18 in. bore; weight 4000 lb. Average results of 9 forgings (or 27 bars)											
	0.35	0.70	0.172	0.008	0.009	2.97	...	102,509	71,572	22.4	53.8
Physical requirements								95,000	65,000	18.0	30.0

closures than the electric steel with low sulphur.

Manufacture of Steel at Naval Ordnance Plant.

From the foregoing physical results and substantiating data, it is evident that the presence of sulphur, oxides, and other non-metallic enclosures are detrimental to the ductility and toughness of steel. Where the best quality of steel is required, it is necessary to keep these impurities to a minimum. The basic open-hearth furnace eliminates the phosphorus but only slightly reduces the sulphur; the oxides must be eliminated by the addition of deoxidizers, such as ferro-manganese, ferrosilicon, aluminum, etc., which are sometimes added to the open-hearth furnace and rabbled after the air is shut off but more frequently are added to the metal in the ladle. If added in the ladle, the reactions are incomplete and the products of combustion remain suspended in the steel, forming harmful non-metallic inclusions. Gun forgings and other ordnance material, where transverse tests are required, have never been successfully made from basic open-hearth steel. The bars generally fail in elongation and reduction of area tests, because of the presence of these inclusions. They generally break with a laminated and woody fracture.

The acid open-hearth furnace is better for making steel free from oxides and non-metallic impurities, and ordnance forgings have been obtained from acid open-hearth steel. While neither phosphorus nor sulphur can be eliminated in this furnace, the amount of these impurities may be kept down by the selection of high-grade scrap and pig iron. The oxides may be largely eliminated by the effective reaction between the slag and the steel.

The method of making steel at the U. S. Naval

Ordnance Plant aims for the elimination of phosphorus, sulphur, and oxides. The metallic charge of the open-hearth furnace consists of 40 per cent. basic pig iron and 60 per cent miscellaneous scrap, including turnings, crop ends, etc., up to 8 per cent of limestone is added with the charge and sufficient ore to lower the carbon to approximately 0.20 to 0.25 per cent, which is slightly below the amount required in the finished steel.

The pig iron has the following approximate analysis: Carbon 3.50 to 4.00 per cent, manganese 0.95 per cent, silicon 0.65 per cent, phosphorus 0.15 per cent and sulphur 0.04 to 0.05 per cent. The crop ends are usually low in phosphorus and sulphur, being the discard from ingots made at this plant by the electric refining process. The miscellaneous scrap, consisting of boiler plate, punchings, and turnings, average approximately 0.04 to 0.05 per cent phosphorus and sulphur.

The limestone shows the following analysis: SiO_2 1.43 per cent, $Fe_2O_3 + Al_2O_3$ 0.60 per cent, $CaCO_3$ 97.54 per cent. A small quantity of fluorspar added to the slag has a negligible effect upon the analysis.

The average analysis of the final slag taken from the open-hearth furnace on nineteen consecutive heats just before tapping is as follows: SiO_2 15.43 per cent, FeO 19.27 per cent, Al_2O_3 3.66 per cent, MnO 8.02 per cent, CaO 45.02 per cent, MgO 6.37 per cent, P_2O_5 1.80 per cent, S. 0.031 per cent.

The average analysis of the steel prior to tapping these same heats was as follows: Carbon 0.23 per cent, manganese 0.26 per cent, silicon 0.010 per cent, phosphorus 0.007 per cent, sulphur 0.015 per cent, nickel 0.66 per cent, chromium 0.00 per cent. After it is tapped from the open-hearth furnace into a 75-ton ladle, the steel is teemed through a 2½ in. nozzle into two 40-ton basic electric furnaces for deoxidizing and finishing. Usually 2 lb. of 50 per cent ferrosilicon and 3 oz. of aluminum for every ton of steel tapped from the open hearth are added to the ladle, to take up any oxygen present, which might lower the carbon content while the steel was in the ladle.

An average analysis of the slag in the ladle from the nineteen heats, after teeming into the 40-ton furnace was as follows: SiO_2 17.27 per cent, FeO 18.32 per cent, Al_2O_3 5.75 per cent, MnO 7.84 per cent, CaO 42.79 per cent, MgO 8.15 per cent, P_2O_5 1.65 per cent, S 0.028 per cent.

The average analysis of the metal as teemed into the electric furnaces from the open hearth on the same heats was as follows: carbon 0.20 per cent, manganese 0.23 per cent, silicon 0.037 per cent, phosphorus, 0.007 per cent, sulfur 0.016 per cent, nickel 0.67 per cent, chromium 0.00 per cent. Both the furnace and the ladle slags show a slight increase in silica and alumina, which may be caused by the addition of the ferrosilicon and aluminum into the ladle. Some of these same elements may have been washed from the sides of the ladle and floated up into the slag. A comparison of the steel analysis will show that the silicon increased slightly; also, that there was a slight drop in carbon and manganese while the steel was in the ladle. The average phosphorus content of the charge into the open hearth was about 0.08 per cent, because of the comparatively low phosphorus in the crop ends.

After teeming the molten open-hearth steel into the 40-ton electric furnaces, a new slag is made up of burned lime, fluorspar, and ground coke. This represents, in weight, about 3 per cent. of the metal charged and is added from time to time, depending on the condition of the bath and the consistency of the slag. The operation from now on is a deoxidizing one. Under normal conditions, the bath is held from 3 to 5 hr. in a reducing atmosphere. The burned lime used in making up the new slag from the electric furnace showed the following analysis: SiO_2 2.50 per cent, Fe_2O_5 + Al O_3 1.50 per cent, CaO 68 per cent, MgO 20 per cent; loss on ignition 8 per cent. The MgO content is higher than usual, but a local lime is used for economic reasons; regular practice limits the MgO content to 5 per cent.

The final slag from the electric furnaces, after finishing the steel, showed the following approximate analysis on six consecutive heats:

SiO_2, Per Cent.	Fe, Per Cent.	Al_2O_3, Per Cent.	Mn, Per Cent.	CaO, Per Cent.	MgO, Per Cent.	P, Per Cent.	S, Per Cent.	CaC_2, Per Cent.
15.10	0.64	1.98	0.27	58.24	16.13	0.020	0.281	1.23
8.16	0.70	3.32	0.11	64.01	16.98	0.067	0.281	1.14
11.97	0.66	1.74	0.53	57.95	14.53	0.082	0.188	0.97
9.20	0.58	4.39	0.40	61.76	12.77	0.044	0.360	1.31
4.32	0.74	2.63	0.14	63.11	16.21	0.016	0.393	1.30
17.60	0.49	3.26	1.05	58.32	13.28	0.030	0.337	1.33

The high MgO in these slags comes from the high MgO in the lime used. The low sulphur is caused by the low sulphur in the charge. The high basicity of this slag and its freedom from metallic oxides, compared with the slag from the open-hearth furnace, should be noted. Unless the slag and steel are thoroughly deoxidized, it would be impossible to form the carbide slag, without such a slag, it would be impossible to eliminate the sulphur from the steel.

The finished steel on these same six heats showed the following analysis:

Carbon, Per Cent.	Manganese, Per Cent.	Silicon, Per Cent.	Nickel, Per Cent.	Phosphorus, Per Cent.	Sulphur, Per Cent.
0.32	0.71	0.250	0.36	0.022	0.009
0.36	0.74	0.241	3.03	0.013	0.008
0.29	0.74	0.238	2.78	0.010	0.007
0.35	0.71	0.200	0.31	0.013	0.008
0.38	0.67	0.210	2.97	0.010	0.008
0.30	0.78	0.215	2.83	0.013	0.010

The low sulphur in the final slag denotes the possibility of removing a greater amount from a steel of higher sulphur content from the open hearth. This would result from using a lower grade of scrap and pig iron with higher sulphur content in making up the charge for the open-hearth furnace. This might occur in plants where miscellaneous scrap is purchased in the open market and where crop ends are not so low in sulphur as those at this plant.

Description of Reactions.

The reducing atmosphere and high temperature existing in the electric furnace permit the following reactions: When the molten steel comes from the open hearth, it contains oxides, principally in the form of FeO and MnO. As the MnO is less soluble in the molten metal than the FeO, it rises to the slag, which has been added on top of the steel as teemed into the electric furnace. This slag contains CaO and C. As the MnO rises to the slag, the following occurs:

$$MnO + C = Mn + CO \qquad (1)$$

The Mn goes back to the bath and the CO is liberated as a gas. When the Mn goes back to the bath, the following reaction takes place:

$$FeO + Mn = Fe + MnO \qquad (2)$$

Reaction (1) again takes place. When this reaction is complete and all metallic oxides eliminated from the slag, another reaction between the lime and carbon takes place, in which calcium carbide is formed:

$$CaO + 3C = CaC_2 + CO \qquad (3)$$

This reaction, however, will not be stable as long as there is a migration of either MnO or FeO from the bath to the slag. In this case, the following occurs:

$$CaC_2 + 3MnO = CaO + 3Mn + 2CO \qquad (4)$$

or

$$CaC_2 + 3FeO = CaO + 3Fe + 2CO \qquad (5)$$

As long as the slag retains its carbide condition after repeated rabbling, it may be assumed that the bath has been freed from oxides. When reaction (3) becomes stable, it is possible to eliminate the sulphur from the steel.

The sulphur is present as FeS and MnS. As calcium has a greater affinity for sulphur than either Fe or Mn, its presence in the slag causes the following reaction:

$$3FeS + CaC_2 + 2CaO = 3Fe + 3CaS + 2CO \qquad (6)$$

and

$$3MnS + CaC_2 + 2CaO = 3Mn + 3CaS + 2CO \qquad (7)$$

The Fe and Mn return to the bath, the CO goes off as a gas, while the CaS is held in the slag. If for any reason the slag should take up any metallic oxide, the conditions expressed in equations (6) and (7) would be reversed and the calcium would give up the sulphur as follows:

$$CaS + FeO = FeS + CaO \qquad (8)$$

or

$$CaS + MnO = MnS + CaO \qquad (9)$$

A simple test for the presence of CaC_2 in the slag may be made by sprinkling water on the slag.

Acetylene gas is given off as a result of the following reaction:

$$CaC_2 + H_2O = CaO + C_2H_2$$

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*Refractories In The Steel Plant**

General Discussion Dealing with the Investigations Made on Refractories During the Past 20 Years—Necessary to Establish Suitable Specifications.

By W. A. HULL
Chief of the Refractories Section Bureau of Standards, Washington, D. C.

IF THE manufacturer who uses refractories can count on a furnace for the term of uninterrupted production, which experience has established as reasonable, then he can co-ordinate that furnace with the rest of his plant unit and depend on uninterrupted production. It goes without saying, that any addition to the established life of the furnace is a distinct gain, but the vital thing is immunity from the unexpected shutdown. The dread of the production man is the lot of brick that will not go the distance, and his complaint when he finds evidence of nonuniformity in an established brand of fire brick comes from the heart.

The question of price is one of the big stumbling blocks in the way of improvement. It is, perhaps, not going too far to say that the greatest transgressor in delaying progress is the purchasing agent. Not until the information gained by the production man and the metallurgist penetrates to his sanctum in sufficient quantities to produce an effect can the refractories question be said to be on a fair way to a satisfactory solution. Progress has already been made in this department, but the more rapidly it becomes general, the better.

One of the great handicaps of the purchasing agent is the almost total lack of specifications. Both manufacturers and consumers of refractories have been rather gun shy on this point; and in the writer's judgment it is one of the things that they will have to come around to and get together on in order to make the best speed. Up to this time the matter of specifications has been left too much to the fire brick manufacturers; and their tendency is to make specifications fit the brick which they make, and with which they are familiar, rather than to make them to fit service requirements. Obviously this is putting the cart before the horse; for the purpose of a specification is to secure a quality that will meet a definite requirement. In refractories, as in other things, the user is in a better position to describe what he requires than is the man who proposes to make the article. If the user makes a specification that simply corresponds to the material which he is already obtaining, it will, of course, serve a certain limited purpose, but if he knows the qualities actually required for a given service and can describe those qualities in terms of a few simple tests, he can draft a specification that will bring in the kind of brick he wants. It may not be on the market when the specification is made, but if it represents an established demand for any large tonnage of refractories, it will furnish a definite goal worth working for. There is a definite service to be performed by the specification that is simply set up to shoot at. If it is anything within reason, somebody is going to hit it, simply because it is there to aim at. Of course, the user must actually buy brick on specifications that can be met at once, but they should not be drawn to the level of what the majority of producers are turning out. Another important point is to keep the number of specifications small so that the producers can market a large tonnage of brick made to one specification. In order to carry this principle to its logical conclusion, the specifications of different consumers should be unified as far as possible. The refractories producers can co-operate effectively in this, and there is no doubt that they will; but there is a tendency which has been found to prevail in many cases which must be guarded against. This is the tendency to hold the specification down to the level of the average producer or even of the tail-ender.

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The Bureau of Standards is the logical clearing-house to serve both consumer and producer in the preparation and unification of specifications. It can, perhaps, be of greater service to consumers than to producers because the former are less united and their problems are so diversified. The Bureau is now working in co-operation with consumers, distributors and producers on the preparation of specifications for certain materials. It is surprising how many important commodities are being bought without specifications and how much difference is found in the quality of different makes of the same article, all of which look to be substantially alike. There is no question that in certain lines some manufacturers are making and marketing an inferior product without knowing it, simply because no standard of quality exists.

Granting that a specification should be made to conform to the service requirement, the first essential to the preparation of any specification is a knowledge of the properties in the refractory which determine its life under the given conditions. The fact that specifications are not now available is probably due, not so much to a lack of appreciation of their potential value, as to an underlying uncertainty as to the application of any proposed set of test requirements in actual service. A test, in order to be of practical value, must be one that can be made conveniently and in a comparatively short time. In actual service, the fire brick must last a comparatively long time. It naturally follows that the tests considered in connection with proposed specifications are what are called accelerated tests—something that will determine a given property of the material rather quickly. This in itself demands a departure from service conditions. Also, there are a good many agencies affecting the life of a brick in service which it would be extremely difficult to duplicate in anything except in actual service test. For example, it would require a good deal of preliminary research to make it possible to approximate in a test the destructive action of the fluxes in the atmosphere of an open hearth furnace or an electric furnace. Testimony has been given by prominent men outside the steel industry to the effect that they have found important differences in the service of different grades of brick which they have not been able to connect with differences in their properties, as shown by any of the tests that they have applied.

In other lines than refractories, extended research has been found necessary to the preparation of suitable specifications. For example, the Bureau of Standards has recently prepared, after much preliminary work, a specification for leather belting. In the course of the study of this problem a number of surprises were encountered, one of which was that the best belting was not the strongest. In the case of refractories, it has long been recognized that the most refractory brick are not the best for all purposes and that there was much to be learned about the relation of other determinable properties to service requirements. The work of the Bureau, up to this time, has been devoted largely to the study of some of these properties and the development of tests for determining them. A portion of this work has already been referred to, but it seems worth while to consider it somewhat more in detail.

One of the first and most fundamental of the investigations taken up was that reported in Technologic Paper No. 10, on the "Melting Point of Fire Brick," by Dr. C. W. Kanolt. In this paper a scientific discussion of the problem, including a consideration of the fact that fire brick do not have a true melting point, is to be found. Determinations were made of the melting points of 62 samples of fire brick and of materials of importance in the manufacture of fire brick. These samples included fire clay brick, bauxite brick, silica brick, magnesite brick, cromite brick, kaolin, pure alumina, pure silica, bauxite, bauxite clay, and chromite. Temperatures were measured with an optical pyrometer. .An improved method of calibrating optical pyrometers is described. It is needless to call attention to the importance of the fundamental data furnished by a work of this kind when done in the thorough and painstaking way in which this was done.

Although a correct knowledge of the melting points of refractory materials is of fundamental importance to investigators, it was realized, by those studying problems connected with refractories, that the ability of a given grade of brick to stand up at a given temperature under furnace conditions, could not be judged within sufficiently close limits by the melting points. Due to viscosity, some materials would preserve their form in a fusion test at temperatures higher than they would stand in a furnace where they were subjected to at least a moderate load. In order to develop a test which would more nearly approximate service conditions and be of value in the practical testing of refractories, a large amount of work was done by the Bureau and was reported in Technologic Paper No. 7, by A. V. Bleininger and G. H. Brown. This report is entitled: "The Testing of Clay Refractories, with Special Reference to Their Load Carrying Ability at Furnace Temperature." General consideration of the refractoriness of fire clay bricks, their viscosity at furnace temperatures, nature and manufacture of refractory clays, effect of accessory constituents upon softening temperatures, effect of fluxes on refractories, effect of heat upon dehydration, contraction, crystallization, and load carrying capacities, are included as well as a large amount of test data. A brief summary of the conclusions includes the following points:

Referring to a clay material which is sufficiently plastic so that no bonding material is necessary, it is stated that "a pure clay of moderate plasticity would be the ideal material for the manufacture of fire bricks." It was found that at the temperatures employed, the presence of even a small amount of fluxes becomes a potent factor and the superiority of a clay high in silica and low in fluxes over one possessing the silica-alumina ratio of kaolin, but higher in fluxes, was shown. The danger of the combination, including both high silica and high fluxes, was pointed out, as was the importance of the size of grain. The importance of the effect of fluxes on the ability of refractories to carry load was emphasized.

In regard to grog, or pre-burned clay, we find the following statement: "Its function from the standpoint of load-carrying ability is two fold: By proper sizing it may be made to improve the mechanical strength of the product; by using grog, consisting of high-grade clay and grinding part of it fine, the standing up quality is improved."

In connection with the consideration of the manufacture of refractories from flint and bond clay, the following recommendations were made:

"If a flint bond clay mixture should prove unsatisfactory as regards its ability to carry loads, the first step would be to cut down the amount of plastic clay, if possible. If this should not be feasible or beneficial, the plastic material would be improved by grinding it intimately with a portion of the flint clay to such a degree of fineness as would insure thorough incorporation. This could be done by dry, or preferably wet grinding. In the latter case it might be possible to pug the additional coarser flint clay into the slip, which naturally would be maintained as thick as possible. The finely ground flint clay would not remain inert, but would of course develop some plasticity."

"By paying attention to the sizing of the ground clays so as to produce as dense a structure as possible, by the use of less water and by adopting dry pressing, the load carrying capacity of the fire bricks would be increased. Likewise, burning at as high a temperature as possible assists in bringing about the same result. Experiments carried on by the writers have shown that harder burning has increased the strength of fire bricks appreciably.

"Unfortunately, the users of refractories do not realize the cost of producing high grade ware, but insist upon low prices, which do not permit the manufacturers to exercise that care in the selection, mixing, sizing and burning of the products which is necessary for the best results. It is self evident that this is poor policy as the initial cost of the refractories is very small compared with that of repairs and the loss caused by shutdowns."

One of the points brought out in the discussion of specifications, which follows, is that for many purposes, products of No. 2 grade are far more suitable than the more expensive high class refractories. It is believed that the importance of this fact is much more generally realized in 1921 than it was in 1911, when this paper was published.

In connection with the recommendations made in this paper as to the mixing of fine ground flint clay with the less refractory bond clay, to improve the refractory qualities of fire clay bricks, it should be noted that at this time bricks are being made for a trial lining for a blast furnace at Cleveland, Ohio, in which this principle is being carried out. A portion of the bond clay for these bricks is replaced by bauxite. The material used is a waste product of bauxite mines. The amount used represents approximately 10 per cent of the total raw batch. The results of this service test will be watched with much interest.

At the end of this paper on load testing, the authors submit a set of suggested specifications for three grades of refractories. These will be given in detail further along in this paper in connection with other specifications.

The following investigations made by the Bureau, while of more general application than the foregoing, are of value in connection with the study of refractories for various purposes:

Technologic Paper No. 17—"The Function of Time in the Vitrification of Clays."

Technologic Paper No. 2—"The Effect of Overfiring on the Structure of Clays."

Technologic Paper No. 23—"Use of Sodium Salts in the Purification of Clays and in the Casting Process."

Another investigation of importance was reported in Technologic Paper No. 79, "Properties of Some European Fire Clays," by Bleininger and Schurecht. This was published in 1916. The properties of five well-known European fire clays used in the manufacture of glass, refractories, graphite crucibles, etc., were studied. Methods that had been developed in the Bureau for attacking problems of this sort were employed. The content of shrinkage and pore water, the drying shrinkage, fineness of grain, mechanical strength in the dry state, the Atterberg plasticity number, rate of vitrification and softening temperature were determined. A comparison of these materials as to their suitability for several purposes, was given, and tentative specifications were suggested for the selection of clays which might be used as substitutes for these foreign materials. American clays are available which, if used as mixtures, can take the place of the imported clays with equally as good or superior results.

In Technologic Paper No. 104, "The Effect of Size of Grog in Fire Clay Bodies," the following findings were reported:

The effect of the size of the calcined portion, or grog, upon the properties of the fire clay bodies is as follows: Strength of the raw body depends upon a number of factors and does not vary with the size of the grog. Strength of burned bodies increases directly with decrease of the size of grog. In quenching tests from 600 deg. C. and 1000 deg. C. mixtures of the larger sizes of grog gave the more resistant bodies. Application of results and European practices are given brief consideration in this report.

The large amount of data on the properties of American bond clays is given in Technologic Paper No. 144, "Properties of American Bond Clays and Their Use in Graphite Crucibles and Glass Pots," by A. V. Bleininger.

"The physical properties of three typical German clays formerly imported in large quantities were described in detail and on the basis of constants, which make possible accurate comparison and evaluation of American materials. Similarly the physical characteristics of 23 American and 2 English bond clays were determined. Of these, several approach the Klingenberg and Grossalmerode clays quite closely. Others by suitable blending can be made to equal or excel the European clays."

It is stated in this paper that for crucible making the best clays should show a pore shrinkage water ratio of not more than 1:1; a modulus rupture for a clay sand vitrification point of 1150 deg. C. or lower; no marked evidence of overfiring at 1400 deg. C., and a softening point corresponding to Orton cone 31, or above. For glass pots, the best materials should show a pore shrinkage water ratio of not more than 1:1; a modulus of rupture, when mixed with equal weights of sand, of not less than 250 pounds per square inch; a vitrification temperature of approximately 1275 deg. C.; an overfiring temperature not below 1425 deg. C., and a softening point equivalent to Orton cone 29, or above.

An extremely comprehensive piece of work and one having an important bearing on the matter of specifications, is that reported in Technologic Paper No. 159, by G. A. Loomis, entitled "Porosity and Volume Changes of Clay Firebricks at Furnace Temperatures." In this paper the methods of test for refractories already in use are discussed. Sixty-one kinds of brick from different sections of the country, made by different processes, were studied. Changes in porosity and volume taking place in these refractories when heat treated at temperatures up to 1450 deg. C. are given. The behavior of the different bricks as change in volume and porosity is correlated with the behavior in the load tests and with their softening points.

The following discussion of the application of porosity and volumes change determinations on fire clay bricks, is given:

"The determination of porosity or volume changes of fire clay bricks, burnt at some temperature between 1350 deg. and 1425 deg. C. affords a means of separating a certain proportion of bricks which would fail in the load test. The limits of 3 per cent in volume change (or 1 per cent in linear contraction or expansion) and 5 per cent decrease in porosity at 1400 deg. C. do not eliminate all bricks which cannot withstand such a test, but materially reduce the number which would require such testing. In this respect it would be of considerable advantage in comparing the quality of a large number of samples, since the porosity and volume changes may be determined readily from a single burn in a test kiln. To make standard load tests on a number of bricks requires considerable time and expense, even if several furnaces were available.

"The determination of volume changes is comparatively simple when porosities are also determined, since the difference in the wet and suspended weights of the specimens affords a measurement of volume practically as accurate as by means of the volumenometer.

"The porosity and volume changes in burning may also be used advantageously as a means of determining the uniformity of quality of a lot of bricks of a single brand. The behavior of such bricks should be fairly uniform if they be of equal quality. Such application of these measurements would be of value to the manufacturer as well as to the consumers.

"A study of the curves for porosity and volume changes for a series of burning temperatures offers a means of determining, in some measure, the causes of failure of certain bricks in the load test. If this is due to underburning, resulting in excessive deformation under load due to shrinkage, a considerable decrease in porosity and volume will be found at the lower burning temperatures. Clays of inferior quality which overburn will be detected by marked expansion at some point in the burning, usually accompanied at a somewhat higher temperature by an increase in porosity due to vesicular structures, show gradual but marked contraction and decrease in porosity as the burning temperature is increased."

The results of the work are summarized as follows:

1. Bricks which are capable of withstanding a pressure of 40 pounds per sq. in. at 1350 deg. C. generally show slight changes in volume or porosity when burnt at temperatures below 1425 deg. C.

2. The greater number of the bricks which failed to pass the load test show rather marked change in volume or in porosity at some temperature below 1425 deg. C.

3. Bricks which show distinct overburning by pronounced expansion at temperatures below 1400 deg. C. invariably fail in the load test. The adoption of a definite limit for the permissible expansion within the given temperature range is particularly important for detecting inferior clay refractories. The limit of expansion should be lower than that for the allowable contraction.

4. The changes in volume and in porosity of bricks burnt at some temperature between 1350 deg. C. and 1425 deg. C. serves, in a measure, as a criterion of their ability to pass the load test.

5. Most of the bricks which show a porosity decrease not exceeding 5 per cent and a volume change not exceeding 3 per cent (approximately 1 per cent in linear dimensions) when burnt at 1400 deg. C. will pass the load test.

6. Bricks which show a decrease in porosity exceeding 5 per cent or an expansion or contraction in excess of 3 per cent by volume (1 per cent in length) at 1400 deg. C. in nearly all cases failed to pass the load test.

7. The use of limiting porosity and volume changes for clay fire bricks burnt at 1400 deg. C. would serve as a means of eliminating from consideration a large number of bricks which fail in the load test.

8. Bricks which fail in the load test due to failure in the bond may not show marked changes in volume or porosity in burning, but often show very low cold crushing strength.

9. No definite relationship seems to exist between the softening point of a fire brick and its ability to withstand load at high temperatures. However, all bricks which softened below cone 28, whether silicious or not in character, failed completely in the load test. It seems advisable then to specify cone 28 as the minimum softening point for any clay fire brick. It is probable that bricks containing less than 65 per cent SiO_2 should have a minimum softening point of cone 31.

10. Bricks with an initial porosity below 21.5 per cent and with an average decrease of about six points in percentage of porosity, contracted about 5.5 per cent in the load test. Bricks showing an average porosity above 21.5 per cent showed a like contraction in the load test with a change of about three points in porosity percentage.

The foregoing paragraphs treat exclusively of fire clay refractories. Next in importance come silica refractories and some extremely good work has been done in the study of the properties in behavior of these materials. The major part of that done by the Bureau has been reported in Technologic Paper No. 116, by D. W. Ross, entitled "Silica Refractories—Factors Affecting Their Qualities and Methods of Testing the Raw Materials and Finished Ware," and Technologic Paper No. 124, by Insley and Klein, entitled "Constitution and Microstructure of Silica Brick and Changes Involved Through Repeated Burnings at High Temperatures."

Important contributions on this subject made by Fenner of the Geophysical Laboratory, and McDowel of the Harbison-Walker Refractories Company, and by others, are referred to in these papers.

Technologic Paper No. 116 covers the subject of silica refractories in a rather comprehensive way, dealing with the raw materials in different sections of the country, with problems of manufacture, and the use of silica refractories, methods of test as well as technical matters connected with the composition of these refractories, the transformations occurring in the burning and the bearing of these transformations on behavior in use are treated at considerable length. The results of a large amount of work on the effect of burning silica refractories of various compositions at different temperatures, and for different lengths of time, are given. The results of a study of resistance to slag action are also included. The author's summary follows:

"In conclusion, it may be said that in general the most satisfactory quartzites for silica refractories are those which contain not less than 97 per cent of SiO_2 nor more than 0.40 per cent of alkalies, and are made up of tightly interlocking grains. The geologic age of quartzites actually used in the manufacture of silica brick in the United States at the present time ranges from cretaceous to pre-cambrian. The harder portions of the Medina formation in Blair and Huntingdon Counties, Pa., have proved to be particularly suited for steel furnace work. Approximately 60 per cent of the silica brick manufactured in the United States at the present time is made of this material. The balance comes largely from the Baraboo formation of Wisconsin.

"Raw brick made from such quartzites should not show undue increase in pore space on being repeatedly burned in a commercial kiln to approximately 1350 deg. C. Two limiting factors in the use of quartzites are impurity, resulting in low softening temperature and friableness, which results in weak brick. Amorphous silica, chert, and chalcedony, when in solid rock form and of desired purity, may also be satisfactory for the manufacture of silica brick, but as yet have not been thoroughly tried out in the United States Their rates of transformation on being heated are, however, appreciably greater than that of quartz. Hence they should be heated more slowly to prevent their disruption.

"As now manufactured, the usual upper limit in the size of fragments present in silica refractories is slightly more than ¼-inch diameter. In the case of brick made from Medina quartzite, those containing coarse fragments tend to spall less than those made of finer material. The slagging effect produced by many basic slags should be kept at a minimum by low porosity, large fragments and by using quartzites having tightly interlocking grains.

"It is probable that the nonuniformity of finished brick, due partly to present methods of grinding of mix and molding of bricks, may in special cases be somewhat minimized by crushing the quartzite in a dry pan to the proper size, screening, then mixing in proper proportions in a mechanical mixer similar to a concrete mixer, which will not further crush the material, and finally molding by machinery under a pressure of approximately 1500 pounds per square inch. This would also improve shape and finish of the brick.

"In the burning of silica brick, the volume of the solid material increases from 10 to 15 per cent of its own volume, owing to the transformation of quartz to the lower specific gravity forms of silica, but since the average porosity of such brick is approximately 26 per cent the exterior volume expansion of the brick will be somewhat more than this. The porosity of a well-burned brick is usually greater than that of the raw mix. In silica refractories there is but a small percentage of flux; hence in burning the quartz is transformed directly to cristobalite. However, when approximately 70 per cent of the material has been converted to cristobalite, tridymite makes its appearance and is developed slowly with continued heat treatment, gradually reducing the amount of cristobalite present. A few per cent of quartz plus silicate glass remain, however, even at a very advanced stage of burning. This is probably mostly silicate glass. In the usual silica brick mixes containing 2 per cent of lime the transformation to forms of lower specific gravity is very slow below 1350 deg. C., but above that temperature, and at a temperature of 1500 deg. C. a close approach to minimum specific gravity is reached in a couple of hours. With a given heat treatment at temperatures from 1200 deg. to 1350 deg. C., the 2 per cent of lime causes the quartz to be transformed much more rapidly than is quartz alone. Greater percentages of lime accelerate transformation still more. The presence of lime in silica refractories causes their softening temperature to be much more clear cut, because of increased fluidity, than is that of pure quartz.

"In burning, to produce a brick of low porosity and low specific gravity, the temperature should be gradually raised to approximately 1250 deg. C. and held between that temperature and 1350 deg. C. for several days to insure transformation of quartz at a moderate rate, and at the same time obtain the effect of soaking. The temperature should then be gradually raised, so that the maximum of the heat treatment is approximately equivalent to cones 18 to 20. Such treatment should produce a brick containing a considerable percentage of tridymite. However, the production of a brick composed entirely of tridymite appears to be impracticable commercially. Rapid rising of the temperature from 1250 deg. C. on, tends to produce undue increase in pore space.

"Since most commercial silica brick are largely cristobalite, their chief spalling tendency is at the alphabeta cristobalite inversion (220 deg. to 275 deg. C.) Also such brick, when heated as in the load test, show a very marked volume expansion at this temperature range, then a gradual but very small additional expansion continues to take place with rise of temperature, until a temperature of approximately 1400 deg. C. is reached, at which point expansion due to transformation of any unaltered quartz present in the brick becomes apparent on the expansion curve. This latter expansion will appear as the permanent expansion when the brick is cold. Thus, it is rather difficult to state the coefficient of expansion of silica brick as a single figure.

"Since check heat treatments of silica brick are difficult to make, the only satisfactory way of actually comparing the amount of expansion of different varieties is to use a heat treatment which is sufficient to insure approximately minimum specific gravity. The specific gravities of practically all commercial silica brick lie between the limits of 2.650 and 2.270 The relative positions between these two points of the specific gravity of a brick, as it comes from the manufacturer, clearly denotes the degree of burning which it has received in manufacture, and in conjunction with the porosity indicates approximately how much the brick will subsequently expand in use.

"The use of silica refractories is limited largely by the degree to which the quartz grains are bonded together in the fragments and by the degree to which the fragments are bonded in the brick.

NEWS OF THE PLANTS

The Whitaker-Glessner Company, Portsmouth, Ohio, has completed plans and will soon commence the erection of a one-story addition, to be equipped as a rod mill. It is estimated to cost about $50,000. Headquarters of the company are at Wheeling, W. Va. H. Bowman is chief engineer.

The Merchants' Dispatch Transportation Company, Rochester, N. Y., is completing plans for the erection of an addition to its steel fabricating plant at East Rochester, to be one-story 60x85 feet. It is expected to commence erection at an early date. L. F. West is head.

The Vulcan Iron Works, Hudson Street, Jersey City, N. J., manufacturers of marine iron products, will commence the immediate erection of a new one-story building at its plant, replacing one of the structures destroyed by fire several months ago. It will cost about $18,000. The company also is reported to have plans under way for the erection of other structures to replace former buildings.

The Wolis & Diamond Iron Works, 335 East Thirty-fourth street, New York, N. Y., will commence the immediate erection of a new branch plant at Whitlock avenue and One Hundred and Forty-ninth street, to be about 50x80 feet, and estimated to cost close to $20,000.

The American Steel & Wire Company, 94 Grove street, Worcester, Mass., is planning for enlargements at its South Works, to use a fund totaling about $100,000, being the appropriation allowed this company branch by the parent organization, the United States Steel Corporation, New York, in connection with its expansion fund of $10,000,000, arranged to keep employes at the different mills busy during the present time.

The E. & G. Brooks Iron Co., Birdsboro, Pa., has inaugurated operations at its local sintering plant on a double operating shift. The plant was destroyed by fire some time ago and has been completely rebuilt, with the installation of new machinery and operating equipment.

The Trumbull Steel Company, Youngstown, Ohio, is now operating eight of the 12 mills at its Liberty plant, which has been idle for a number of months past. It is said that operations will be increased to include other mills at an early date.

The Electric Manganese Steel Company, Reading, Pa., recently organized, will commence operations at an early date in its new plant now being completed. The main building will be about 45x100 feet, and has been arranged to allow for the construction of an addition at a later date. The installation will comprise a large electric furnace department. Ray Houck is president of the company.

The Great Southern Steel Company, Chicago, Ill., has been incorporated under Delaware laws, with a capital of $105,000,000, to manufacture iron and steel products of various kinds, including the operation of a blast furnace for the production of pig iron. The company is said to have acquired a large tract of land near Muscle Shoals, Ala., comprising over 100,000 acres, and a portion of this property will be used as a site for a new plant. It is estimated that the tract contains over three billion tons of ore and over one billion tons of coking coal, to be used in connection with the development. The company is represented by Charles E. Pain, First National Bank Building, Chicago.

The Wickwire-Spencer Steel Company, Buffalo, N. Y., has increased operations at its local finishing mill to a point of about 75 per cent of normal. One blast furnace is in operation at the plant. The company also is increasing production at its different New England mills.

The Interstate Iron & Steel Company, Chicago, Ill., has increased production to about 50 per cent of normal at its local mill.

The Youngstown Welding Company, Youngstown, Ohio, has plans under way for the construction of a new steel fabricating plant on local site, comprising about 3½ acres of land, recently acquired. Preliminary work has been inaugurated. Three buildings, each about 100x300 feet, will be constructed during the coming year. The different plant departments will be devoted to plate work, boilers, tanks and kindred specialties.

The Reading Iron Company, Reading, Pa., is now operating at its puddle mill, North Ninth street, where operations have been curtailed for some time past. The Keystone blast furnace of the company was recently blown in, and plans are being perfected for the early resumption of the company's blast furnace at Emaus, Pa. The 14-inch rolling mill at the Reading works will soon be producing.

Plans are being developed for a merger of the Columbia Steel Company, Pittsburg, Cal., the Southern California Iron & Steel Company, Los Angeles, Cal., and the Carbon Fuel Company, Salt Lake City, Utah. It is proposed to increase the capitalization of the different interests and to develop plans for general plant expansion. In this latter connection, both of the plants of the two first mentioned companies will be enlarged, with the installation of new equipment, it is said, to provide for increased outputs. It is proposed, ultimately, to construct a large steel plant in the vicinity of Salt Lake City, including 500-ton blast furnace, coke ovens, etc. W. E. Creed is president of the Columbia Steel Company; A. C. Denman, Jr., president of the California Iron & Steel Company; and L. R. Rains, president of the Carbon Fuel Company.

The Commerce Steel Company, Seattle, Wash., has acquired property in the vicinity of Tekoa, Wash., as a site for the construction of a new blast furnace and steel plant. The property purchased is said to contain large quantities of iron ores, and plans will be placed under way for the construction of a blast furnace with initial rating of about 75 tons. W. C. Hayward is president of the corporation.

The Republic Iron & Steel Company, East Chicago, Ind., has reopened its local plant after a few months of inactivity. About 200 men will be employed at the present time, and which number is to be increased gradually as orders and conditions warrant.

WITH THE EQUIPMENT MANUFACTURERS

WELDING SETS UTILIZE GAS ENGINE POWER

Two types of gas engine driven welding sets, one for medium or intermittent duty and the other for heavy duty, recently have been developed by the General Electric Company, Schenectady, N. Y. Both outfits are adapted to industrial plants where the work to be done is located in odd places and is not of sufficient volume to warrant the installation of permanent equipment. Their particular field, however, is in places where electric power is not available or inconvenient or costly.

The medium duty equipment designed for intermittent duty, has a generating unit consisting of a 4-kw., 1,200-rpm., 60-20 volt, 200-ampere generator directly connected by a flexible coupling to a 4-cylinder, 4-cycle, 20-hp. gasoline engine. The engine, radiator, generator and welding panel are assembled on a cast iron base and mounted on skids. The set is 86 inches long, 28 inches wide and weighs about one ton. The engine is of the overhead valve type with the cylinders cast in block and is well adapted to intermittent service.

Practically constant energy throughout the working range is given by the generator which is self-exciting and regulating. It gives no load or striking voltage of 60 volts, which decreases automatically to the proper welding voltage, 18 to 20 volts, when the arc is struck. Driven at 1,200 revolutions per minute, it delivers a working current of 200 amperes and an output of 4 kw. The panel carries the generator field rheostat and series field dial switch by which the current can be adjusted from 75 to 200 amperes in 25-ampere steps. A reactor choke coil mounted on the set and connected in the welding circuit protects the generator from current surges.

NOVO COMBINATION HOIST AND AIR COMPRESSOR

The Novo combination hoist and air compressor was designed especially for bridge and elevated tank erection or any steel erection work within its capacity. This outfit is also useful for trench work—the hoist being used to lower and place pipe and the compressor for caulking or light rock drilling.

The outfit consists of a Novo Type TN non-reversible hoist driven by gears from a Novo 15-hp. engine. A 6x6-in. single acting compressor, driven by belt on a clutch pulley, is mounted on an extension of the channel frame.

Both hoist and compressor are equipped with friction clutches so that either one may be operated independent of the other.

The hoist is equipped with a drum for handling structural steel members. This drum holds 700 feet of ½-in. cable. The drum shaft also has a niggerhead mounted on each end for handling scaffolding, erecting derrick, etc. The drum is provided with a pin lock for disengaging drum when the niggerheads are to be used for other work.

A contracting band friction clutch is mounted on the intermediate shaft for operating the drum or niggerheads and a powerful asbestos-lined foot brake equipped with a ratchet lock is supplied to hold the load.

The compressor has a displacement of 60 feet per minute, which is ample for handling one riveting hammer, caulking, light drilling, reaming, etc. The compressor is provided with a circulating pump and a tank for cooling water. It also has a visible overflow arrangement to show the performance of the circulating pump. An unloader is provided for cutting out the compressor when the supply of air exceeds the demand. The unloader is adjustable and entirely automatic in its operation.

The crank case of the compressor is enclosed and is cast separate from the cylinder. The latter feature does away with the replacement of almost an entire new machine in case of a brake in either cylinder or crank case, as it is only necessary to purchase the broken part.

The lower part of the crank case is filled with oil and at each revolution of the shaft the connecting rod splashes the oil on all bearings, pins, etc. This system of lubrication does away with lubricator, grease cups or oil holes.

The valves are worthy of special notice. Both inlet and discharge are made of light sheet steel; they are very light, seat quickly and quietly without wear on the cylinders and cause the machine to run practically noiseless. No springs are necessary with these valves. The areas are large so that the air can come in and go out freely, without friction. This valve construction is patented.

EXPLAINS BRIDGE CONSTRUCTION

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held at the William Penn hotel, Pittsburgh, Tuesday, December 20. S. F. Fuller, chief engineer of the John F. Casey Company, Pittsburgh, delivered a paper illustrated by lantern slides, on "The Construction of the Monongahela River Bridge at Fairmont, W. Va." The headquarters of the Engineers' Society of Western Pennsylvania now have been established in the William Penn hotel, this city. K. F. Treschow is secretary.

Upon special invitation, the members attended the meeting of the Pittsburgh section, American Institute of Electrical Engineers, held Monday evening, December 19, in the Science building, Carnegie Institute of Technology. A symposium on "Radio Telephony and Broadcasting" was conducted by the following: L. W. Chubb, Westinghouse Electric & Manufacturing Company, discussing "Radio Telephony and Broadcasting;" D. G. Little, Westinghouse Electric & Manufacturing Company, and M. C. Batsel, Westinghouse Electric & Manufacturing Company, describing "Broadcasting Transmitters" and "Broadcasting Receivers," respectively.

MASSILLON STEAM DROP HAMMER

The Massillon Foundry & Machine Company, Massillon, O., has lately redesigned its line of steam drop hammers. The housings are annealed steel castings of I section, machined to fit in deep pockets in the hammer base, which is likewise a steel casting. The cylinder is a semi-steel casting that has been reinforced over the valve. It interlocks in the tops of the housings, so that no tie-plate is required A safety cylinder is provided to protect the hammer in case the piston rod breaks, it being so made that the piston ascends against a cushion of live steam. Any standard type of valve can be furnished. The valve bracket and the steam-inlet bracket can be removed independently of one another.

The ram guides have been arranged to adjust back into the side frames for the removal of the ram horizontally. The side frames just clear the ram, preventing over-adjustment of the guides, which would cramp the piston rod. A feature of the design is that the guide adjusting screws are threaded through nuts set in open pockets in the side frame. This arrangement permits damaged screws to be removed by cutting out the nut with an acetylene torch without disturbing the ram or guides.

FOREIGN RELATIONS

IRON FURNACE COSTS IN CHINA.

Some interesting facts and figures bearing on the cost of production of iron and steel in China, and relating in particular to the Hanyang Iron & Steel Works at Hanyang, where given in a recent issue of the Far Eastern Review, which is quoted here:

The iron ore, of which from 15,000 to 20,000 tons were required every month when three of the four furnaces were under operation in 1919 (perhaps another 8,000 or 9,000 tons would be needed for the fourth furnace) comes from the company's own mines at Tayeh. The cost of its production at Tayeh was below $2.80 per ton (in 1919), but the cost of transportation per ton from Tayeh to Hanyang was $0.85, which, together with other expenses, brought the cost up to about $4 per ton at the Hanyang furnaces. This cost is now much lowered by smelting the ore in the new blast furnaces at Tayeh, but at the same time a greater allowance must be made for coke which has to be transported from Pinghsiang to Hanyang and thence again to Tayeh. As nearly equal quantities of coke and of ore are used in the furnaces, the saving effected in transportation is not of much significance.

Limestone also comes mainly from Tayeh. The cost per ton at the Hanyang furnaces varied in 1919 between $2.32 and $3.81. These figures include all transportation and overhead charges. Manganese comes from the company's mines at Changlai and Yangshin. Those two items amounted in 1919 to 3 or 4 per cent of the total cost.

The next group of items of cost concerns direct wages. This includes not only the wages of laborers working at the furnaces but also of those working at the blowing and pumping plants, both of which are essential adjuncts to the furnaces. The wages of the laborer differ not so much with the group in which he works as with the grade of labor to which he belongs. In general the laborers are divided into four grades, namely, foremen, mechanics, regular laborers, and helpers who are paid by the day. The salaries of the foremen may be in some cases as high as $100 a month, the mechanics receive about $20, the regular laborers from 8,500 to 9,000 cash (at the present rate of exchange between silver and copper about $7 Mexican), and the helpers get only 200 cash a day (about $0.15). In some cases contract labor is employed. The total cost in direct labor constitutes only 0.8 to 1.4 per cent of the total cost of iron production.

IRON AND STEEL PRODUCTION IN RUSSIA.

"During the years 1917 to 1920 Russian industry and transportation drew their metals from the old sources of supply, which accounted for their ability to carry on their usual activities," states the Pravada (Moscow) in a recent issue, and continues:

At the beginning of 1921 it was evident there were very small stocks of metals in the State warehouses, while some of the most useful were entirely lacking. Most of the difficulty prior to 1920 was experienced because of a shortage of fuel, while during the year 1920 it was due to a scarcity of labor and in 1921 to a shortage of raw materials.

For the first quarter of 1920 instead of 2,334,000 poods (pood = 36.1128 pounds) of pig iron required by the Government's program, only 2,144,000 poods were smelted, or 95 per cent of the program. The central region produced 302,000 poods, or 39 per cent of its allotment; the southern region, 270,000 poods, or 108 per cent; and the Ural region, 1,572,000 poods, or 119 per cent.

The production of Martin steel during the first quarter of 1921 declined to a mere 6 per cent of that before the war. In all three regions production aggregated 2,926,000 poods, while in the corresponding quarter of 1913 a total of 51,737,000 poods was turned out.

For the first quarter of 1921 the central region produced 476,000 poods of rolled steel, or 57 per cent of its allotment; the southern region, 720,000 poods, or 120 per cent; the Ural region, 1,290,000 poods, or 81 per cent; a total for all three districts of 2,386,000 poods, or 87 per cent of the Government's program.

NEW BRIDGE FOR SYDNEY, AUSTRALIA.

Specifications to cover the design, construction, and erection of the Sydney (Australia) Harbor North Shore Bridge are expected shortly by the Bureau of Foreign and Domestic Commerce from Trade Commissioner A. W. Ferrin, and upon their receipt copies will be placed on file in the Bureau's New York and Chicago offices, where they may be consulted by interested persons.

The bridge will consist of nickel-steel cantilevers supporting a central girder section, also constructed of nickel steel, spanning the harbor between Dawes Point and Milson's Point. Each anchor or shore arm will be 500 feet long, the harbor or cantilever arms will be 520 feet long, while the central section is to be 560 feet long, thus making a span of 1,600 feet from center to center of the main supporting piers and a total length of steel work of 2,600 feet. Between the main girders, which are 94 feet 6 inches apart, provision is made for four lines of electric railway and a roadway 35 feet wide. Outside the main girders on the east side is a motor roadway 18 feet wide between the handrails, and on the western side a footway 15 feet wide, the railways, roadway, and footway being all on the same grade. A headway of 170 feet above high water is provided for the central 600 feet of the bridge, with a clearance of not less than 156 feet over the whole fairway.

The Sydney Harbor bridge will thus have 5 feet greater span and 35 feet more headway under the center than does Brooklyn Bridge, and will have a span only 200 feet shorter than that of the Quebec Bridge, but with a headway 20 feet greater. The estimated cost of the bridge is £6,000,000, and the work is expected to extend over eight and a half years.

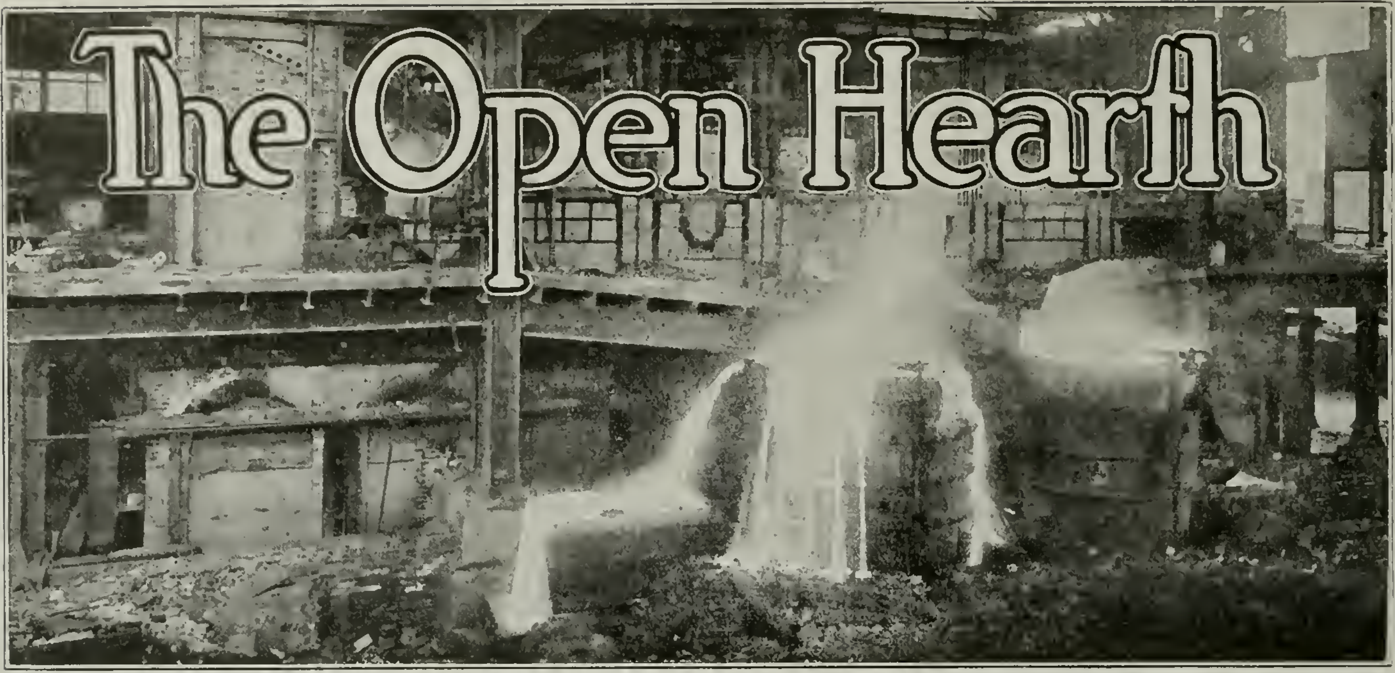
Several new steel companies are in process of organization in China, the Far Eastern Review reporting the organization of the Wu-Shun Steel & Iron Works, of Shanghai, an Anglo-Chinese enterprise, and a steel refining works to be erected by a Shanghai merchant.

FRENCH STEEL OUTPUT FOR SIX MONTHS.

Consul Ernest L. Ives, Paris; see also Commerce Reports for Nov. 28, 1921.

The total production of steel ingots and castings in France during the first six months of 1921 amounted to 1,537,634 metric tons, 1,487,961 tons of which were ingots, and 49,673 tons of which were castings, according to statistics compiled by the Comite des Forges de France. There is an increase of 332,933 tons in the production as compared with January–June (1,204,701 metric tons) and a decrease of 308,061 tons as compared with July–December of 1920 (1,845,695 metric tons).

The Open Hearth



Edward Heldt has been made general manager of the Lincoln Foundry Company recently organized at Merrill, Wisconsin. Mr. Heldt, for twenty years, was connected with various Wisconsin and Minnesota shops.

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Walter Ferrier resigned his connection with the Elyria Iron and Steel Company, Elyria, Ohio, and Cleveland, to become general manager of works of the new Hudson City Steel Corporation, Beacon, New York. Mr. Ferrier was with the steel corporation plants at Homestead, Pa., and Gary, Ind., for eighteen years and later for seven years with the Cambria Steel Company, at Johnstown, Pa.

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A. D. Miles, president of the International Nickel Company of Canada, subsidiary of the International Nickel Co., New York, has resigned, together with G. E. Sylvester, assistant to the president, and W. M. Dennett, assistant treasurer, due to the depression in the industry which resulted in suspensions of the company's mining and smelting operations.

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Horace B. Spackman was recently elected president of the Eastern Pig Iron association. Mr. Spackman is both a producer and a buyer of pig iron. He is president of the Allegheny Ore & Iron Co., which has blast furnaces at Buena Vista and Iron Gate, Va. The company is owned by the Lukens Steel Co. Mr. Spackman also is second vice-president and purchasing agent of the Lukens Steel Company, which is the most important buyer of pig iron in the East.

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Thomas J. Collins, for many years auditor of the Page Steel & Wire Co., Adrian, Michigan, has resigned.

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J. T. Rose was recently appointed collector of internal revenue for Georgia. Mr. Rose is vice president of the J. B. McCrary Co., Atlanta, industrial engineers, and formerly vice president of the Atlantic Steel Co., Atlanta.

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Stewart M. Marshall of the engineering firm of Perin & Marshall, New York, arrived in Japan recently on a trip to India. He expects to spend some time in China.

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Frank Carroll has resigned as chief draughtsman of the Youngstown Sheet & Tube Co., Youngstown, Ohio, to become assistant to the chief engineer of the Inland Steel Co., Chicago.

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R. L. Wahl, chief engineer of Inland Steel Company, Indiana Harbor, Ind., has been appointed acting general superintendent of mines for the company during the illness of William Wearne.

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Wilbert L. Smith of Syracuse, N. Y., has been elected director of the Crucible Steel Co. of America, New York and Pittsburgh, to succeed John W. Daugherty, who retired as a director at the company's annual meeting held in Jersey City, N. J., recently.

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Charles Wilson was recently promoted assistant superintendent of the Enterprise Foundry Co., Auburn, N. Y. He has been with the company four years.

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G. W. Wrenshall has been appointed general manager of the Pressed Steel Car Company, Pittsburgh, in succession to the late J. B. Rider. Mr. Wrenshall was general superintendent of the McKees Rocks plant of that company since 1909. Since Mr. Rider's death, Mr. Wrenshall has been acting as manager. Henry P. Hoffstot, president of the Koppel Industrial Car & Equipment Co., Pittsburgh and Koppel, Pa., a subsidiary of the Pressed Steel Car Company, who was recently elected vice president of the Pressed Steel Car Company, has assumed the vice presidential duties formerly discharged by Mr. Rider. Mr. Wrenshall has had considerable experience in the car building industry, having been affiliated for 12 years with the Southern Car & Foundry Co., as manager and the Western Steel Car & Foundry Co. as superintendent, both at Anniston, Ala.

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A. A. Albaugh, formerly general superintendent Jacobson Machine Mfg. Co., has been appointed vice president and general manager of the Barnhart-Davis Co., Warren, Pa., iron and brass works.

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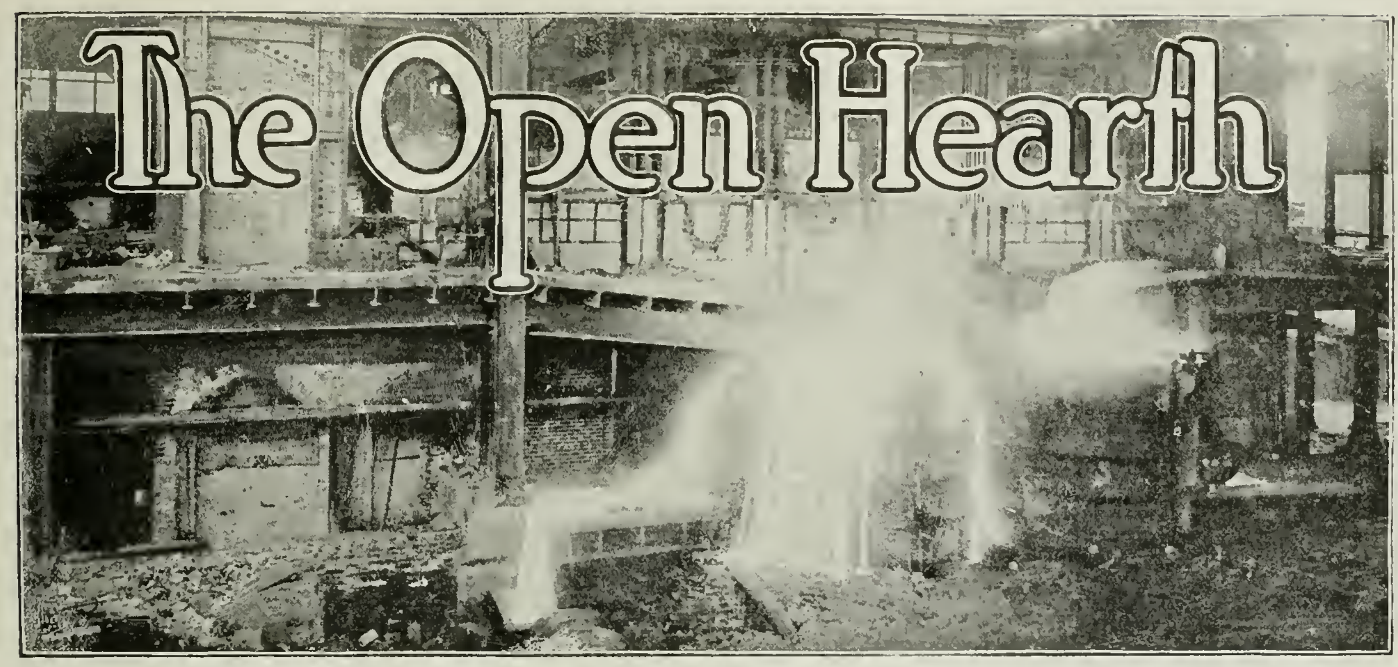
Charles H. Bromley, formerly technical director Richardson-Phenix Co., Milwaukee, Wisconsin, is now manager and chief engineer of the newly formed Richardson-Phenix division of S. F. Bowser & Co., Inc. This division will con-

The Open Hearth



duct the filtration and lubrication appliance business of the consolidated companies, with main office at Fort Wayne, Ind.

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Henry D. Hibbard, consulting metallurgist, Plainfield, N. J., sailed on November 30th for a sojourn in southern France and Italy.

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A. G. Labbe has been elected president of the Willamette Iron & Steel Works, Portland, Ore., succeeding Bert C. Ball, who will devote his time to other interests, chiefly to the Portland Vegetable Oil Mills Co. E. C. Pape, second vice-president, was advanced to first vice-president to succeed Mr. Labbe. N. H. Insley was chosen secretary and H. V. Carpenter treasurer.

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E. A. Wheaton was recently promoted to the position of open hearth superintendent of the Bethlehem Steel Corporation, Sparrows Point plant at Maryland, to succeed F. F. Lines who resigned a short time ago. Mr. Wheaton was formerly superintendent of open hearth department No. 3, Lehigh plant of the above named company, and was graduated from Lehigh University in 1912. He entered the employ of the Bethlehem Steel Corporation following his graduation as a metallurgical enginer. At the meeting of the American Iron and Steel Institute, October, 1920, he read a paper on "High Manganese Iron in Basic Open Hearth Practice."

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W. J. Priestly, metallurgical engineer, United States Naval Ordnance Plant, South Charleston, W. Va., has been chosen chairman of the Board of Registration for Engineers of West Virginia, the body set up by an act of the Legislature. George E. Taylor, Anderson & Taylor, consulting engineer, Charleston, has been elected secretary of the board, the other members of which are Frank Haas, Fairmont, consulting engineer, Consolidation Coal Co.; H. C. Cooper, Clarksburg, general superintendent Hope Natural Gas Co., and N. H. Mannakee, Bluefield, consulting mining engineer.

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E. M. Freeland recently resigned his position with the Sparrows Point, Md., plant, the Bethlehem Steel Corporation to become affiliated with Follansbee Brothers Company, as metallurgist at the company's plant at Follansbee, W. Va.

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E. T. Vogel was recently elected vice president of the Eastern States Furnace and Coke Oven association. Mr. Vogel is superintendent of the Youngstown Sheet & Tube Company, Youngstown, Ohio.

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E. D. Batchelor, district sales manager in St. Louis for the Jones & Laughlin Steel Company, has been made manager of sales of that company's wire department at Pittsburgh, effective January 1, upon the retirement of Mr. Mason. Mr. Batchelor has been with the company more than 32 years, serving first in several departments in the general offices and for 10 years attached to the Pittsburgh sales district. For the past 10 years he has been manager of the St. Louis district.

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John A. Denholm, vice president and assistant general sales manager of the Wickwire Spencer Steel Corporation, and Albert B. Fritts, advertising manager of the Norton Company, both of Worcester, Mass., have been elected president and vice president, respectively, of the Worcester Commercial Travelers' association.

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John Bindley, chairman Pittsburgh Steel Company, Pittsburgh, and for more than 50 years identified with the hardware and steel industries, died at his winter home, El Jardine, Miami, Fla., December 16, death being due to disabilities of age. Prior to becoming chairman of the company, Mr. Bindley had been its president, having been elected in March, 1919, to succeed the late Wallace H. Rowe. He was born in Pittsburgh 75 years ago and had always lived in that city, his larger interests always having been centered in the Pittsburgh district. At the age of 16 he entered the employment of John England, who conducted a hardware store and file factory in Liberty street, near Ninth street. Upon reaching his majority, he became a partner in the business, under the firm name of John England & Co., which later was changed to England & Bindley. A few years later Mr. Bindley purchased the interest of Mr. England, and the firm name was changed to the Bindley Hardware Company. The company was liquidated in 1910. While engaged in the hardware business he became interested in manufacturing, first in the Neely Nut & Bolt Company, of which he was president at the time of his death, and in 1901 in the Pittsburgh Steel Company, of which he was one of the organizers and an original director. Upon the death of his brother, Edwin Bindley, in 1906, he succeeded him as vice president of that company. He was also one of the organizers and a director of the Pittsburgh Steel Products Company.

PRODUCTION TOPICS

A NEW IDEA IN STEEL IDENTIFICATION AND STORAGE

It often happens that, due to an absence of standard equipment on the market or lack of a standard way of doing things, manufacturers are forced to create new methods or devise new equipment that will exactly fit into their particular system of operation, with the result that the new idea evolved and executed is generally an improvement over everything of a similar nature that has preceded it.

Such a condition caused the firm of Gould & Eberhardt to devise the following method of marking their steel bars for identification and also designing and constructing suitable steel storage racks to conform with the highly developed manufacturing system employed in their new plant at Newark, N. J.

Several new ideas in steel marking, together with a novel design in storage racks, is the result of their efforts to solve their own factory problems.

In the manufacture of shapers and automatic gear cutting machinery, they naturally use many different kinds and sizes of steel bars—round, square, hexagon, and rectangular in shape, so this convenient system of storing and marking the various grades and sizes entirely eliminates the possibility of an error in finding the required piece.

Plain colors and combinations of colors play an important part in the scheme of marking the steel, each color having a direct significance with regard to the metallurgical contents or the particular make of steel. The identification colors are painted on the ends of the bars as they are received in the shipping department.

To assist the raw material clerk in selecting the proper steel, a very noticeable identification board is hung above each rack. On this rack are listed all the different kinds of steels the company uses, with a two-inch disk, painted in the corresponding color, opposite each name. The board has a wide background which shows the various colors to great advantage.

The various steels with their corresponding colors as listed on the board are:

30/45 machine	red
High speed tool	blue
Crescent	yellow
10/15 machine	green
Cold rolled	white
O. C. N. S.	Halves of green and red
Simplex	green with white stripe
Tap	Halves of green and white

Each rack is built up of five duplicate sections, spaced four feet apart and properly braced to form a very rigid rack 16 feet long, the entire rack being bolted together with ½-inch bolts.

The individual section has a base consisting of a heavy 8-inch I beam 8 feet long, with 6 heavy 2x2-inch angles, 7 feet high, equally spaced and forming uprights to divide the section into five tiers. These tiers are in turn subdivided by ½-inch rods which extend from top to bottom, thereby making 10 tiers available in each rack.

Cross pieces or shelves on which the steel bars lay are heavy 2x2-inch angles, spaced about 20 inches above each others at the bottom and diminishing in this distance until at the top, where the very small rods are stored; the distance between is about 6 inches. The top piece of each section is composed of a heavy 2x3-inch angle, making a very rigid top brace to complete the frame of the section, and also permitting the storage of extra large diameter short bars on top of the rack.

The five cross sections are spaced and held together to form the completed frame work of the rack by 2x2-inch heavy angle stringers extending the full length of the rack at the top and bottom of each side.

Extra longitudinal bracing is provided by ¼x2½ flat bars crossed between and bolted to the top and bottom of the sections.

An extra angle on each side at the top and extending the length of the rack prevents pieces from rolling off, while further precaution is taken by having timbers with half round notches cut in them extending along the front on top of the rack, permitting short round pieces to be laid in place.

Naturally, the most convenient way to place the steel in the rack would be to have all the steel of the same kind in one tier with the largest and heavier pieces on the bottom and the varying sizes in regular order, according to their dimensions, with the smallest at the top. This order has been reversed wherever possible, in some cases the square, hexagon, or rectangular shaped bars, which are generally smaller in size, being placed on the bottom shelves, and the very heavy bars on the very top so that they may be easily handled with the traveling crane which travels above these racks.

In order to facilitate the placing and location of the various kinds and sizes of steels into their proper places, each rack is given a section number, besides each tier in the rack is lettered and each shelf is numbered, making it a very simple matter to give instructions for the proper location of each bar as it is received, besides assisting to keep stock records and taking inventory.

Much thought has been given to the general design of the rack and also the system of storage employed, both perhaps embodying all the desirable features that Gould and Eberhardt have found to be correct during their 88 years of manufacturing experience.

BIBLIOGRAPHY ON REFRACTORIES.

The Refractory Division of the American Ceramic Society has issued a new bulletin in the form of a bibliography of magnesite and dolomite refractories. Organizing Secretary Ross Purdy, Columbus, Ohio, has collaborated with A. S. Greaves-Walker, chairman of the division.

This is but the first of the bibliographies to be issued by the society. The Refractory Division will shortly issue other bulletins on chromium, sillimanite, alumina, spinel, silicon carbide, zirconia, carbon, clay and special refractories including nitrides and oxides. The U. S. Bureau of Mines, in Columbus, is collaborating in the preparation.

LARGEST ELECTRIC STEEL MELTING FURNACE.

The Ford Motor Co. has placed an order for the largest electric steel melting furnace ever designed. Its capacity will be 9000 kva, which is claimed to be three times the size of any previously installed furnace. It will have six electrodes and will be of the Greaves-Etchells bottom conducting type, sold by the Electric Furnace Construction Co., Philadelphia. This furnace will be the principal melting unit of the new battery of electric furnaces for the Ford company's River Rouge works.

PRODUCTION TOPICS

GROUND TO BE BROKEN FOR COLD-ROLLED STRIP MILL AT BEACON, N. Y.

Ground will be broken at Beacon, N. Y., the first week in January for the cold-rolled strip mill of the Hudson City Steel Corporation, the plans of which were published in "The Iron Age" of August 19, 1920. It will roll strips from 2 to 14 in. wide and from 0.01 to ¼ in. thick and will sell to the general trade. The corporation owns another site at Hudson, N. Y. It is the plan to first manufacture strips, later building open-hearth furnaces thereby making it unnecessary to buy billets and sheet bars.

The mill will have a cold-rolled strip capacity of 1000 tons per month on a 10-hr. day. The equipment will consist of five 10-in. mills, five 12-in. mills, two 25-ton General Electric annealing furnaces, two slitters and two straighteners. Dwight P. Robinson, Inc., New York, will erect the building and install the equipment. Offices of the Hudson corporation are at 2302-4 Woolworth Building, New York, in charge of James S. Landers, vice-president and general manager. The corporation was formed in May, 1920, the capitalization being $500,000.

ELECTRICAL REVIEW OF THE STEEL INDUSTRY DURING 1921

By O. Needham, General Engineer

Westinghouse Electric & Manufacturing Company

The activity in the steel mills during 1921 has not been very great, and therefore there has not been a considerable amount of extension work or new building in connection with them. There has, however, been some quite notable advances made by electricity in the steel mills.

The installation of a reversing motor to replace a reversing engine on the 44-inch blooming mill of the Bethlehem Steel Company at Steelton, Pa., marks the first time that electricity has replaced steam on a reversing blooming mill in this country. Only 23 days elapsed from the time the engine was taken out of service until the motor was put into service. On the third day of operation with the electric motor the mill rolled 1,006 tons on a turn, which was within 40 tons of being the record with the engine. Since then the mill has rolled 1,520 tons on a turn.

Another instance of electricity replacing steam for driving a reversing blooming mill is at the Atlantic Steel Company, Atlanta, Ga. A reversing motor was installed and placed in operation during May and the first part of June, 1921, on a blooming mill, this motor replacing a reversing steam engine.

The Follansbee Brothers have installed in their new plant at Toronto, Ohio, a reversing motor to drive a bar mill. This is the first instance in this country of a reversing motor being used to drive a bar mill. This mill will be used for finishing sheet bar.

A very interesting installation from an electrical standpoint will be the new electrically driven mills of the Driver Harris Company at Harrison, N. J. This installation will consist of a 20-inch mill and a 9-inch mill, each driven with an adjustable speed d.c. motor operated at 600 volts and supplied with power by a common motor generator set. The motor generator set consists of a synchronous motor and a d.c. generator. The point of special interest in this installation is its automatic features. The motor generator set is started up and put on the 2200-volt, 60-cycle circuit by the mere pressing of a push button. The motor generator set, as well as the two mill motors, are equipped with bearing theromstats, and thermal relays are placed in the circuits of all the machines. These thermostats and thermal relays are so connected up that if a bearing temperature rises above a predetermined value or a circuit becomes too much overloaded, they will ring a gong to warn the mill operator. The gong as well as the start and stop push buttons and the meters for the motor generator set and mill motors are placed in the mill pulpit. No attendant is required for the motors and motor generator set, as complete and positive protection is given the equipment by the automatic protective devices.

The Missouri Rolling Mill Corporation recently purchased two adjustable speed d.c. motors to drive a 16-inch and a 9-inch mill. These motors operate from a rotary converter, which receives power from a 13,200-volt, 25-cycle circuit. This installation as well as the Driver Harris Company mill will operate with central station power.

Central station power is used very extensively in the smaller plants and to some extent in a number of the larger ones. Most of the larger companies generate the greater part of their power so that some steel companies have generating station that compare quite favorably with some of our central stations. This means that they are able to utilize some rather large units and thus obtain economies comparable with central stations. The tendency in steel mills is toward the higher steam pressures and superheat used by central stations. Sheel mill stations now use up to about 20,000 kv.-a. operating on 225 lb. steam and 150 deg. superheat.

The question of yard electrification for steel mills has been receiving considerable attention. There has not been any yard electrifications in steel mills up to the present time, but considerable investigation has been going on and it would appear that there is a very fertile field for electrical development in this direction.

Electric energy for heating is opening up an additional field for the use of electricity in steel mills. A number of instances, such as electrically heated babbit, and solder pots, tin pots for tin mills, heat treating ovens, and core drying ovens for foundries are proving successful and demonstrate that electricity can be used in this field.

SHIPPING STEEL ON OHIO RIVER.

Recent shipments of iron and steel from Pittsburgh and various cities along the Ohio River which have the necessary terminals have caused much comment among local business men, the products carried on these trips not being available to Cincinnati because of the difficulty of transferring them from barges to trucks or other vehicles. With proper terminal facilities much business that now goes to other cities would come to Cincinnati and at the same time local consumers would get the benefit of the lower space rates offered by the waterway carriers.

Several plans for terminals have already been worked out by engineers, and it is expected that early action will be taken to build river terminals at some advantageous point on the river front to take care of the ever-increasing shipments of heavy bulk freight into the city. The Chamber of Commerce is active in promoting a concerted effort to this end among the business interests.

TRADE NOTES

On December 15th, the New York Office of the Blaw-Knox Company, was moved from the City Investing Building to the Carbide & Carbon Building, 30 East 42nd Street.

As of December 1st, the Andrews-Bradshaw Company, Sales Engineers, formerly located on the third floor of the B. F. Jones Bldg., Pittsburgh, Pa., have moved to the eighth floor of the same building. They have, by this move, doubled their office space.

Mr. A. D. Keene, Electric Furnace Engineer of the General Electric Company, Schenectady Works, is now connected with the Pittsburgh Electric Furnace Corporation as engineer on electric furnace designs and applications in the steel and metal industries.

The Engineering Advertisers Association of Chicago is now publishing a monthly bulletin in the interest of its members. The Bulletin gives a digest of the speeches made at the various meetings and also includes other information and facts regarding the movements of goods from industry to industry, personal notes, etc. We are advised that at the present time there are a limited number of extra copies of the "Bulletin" which will be sent upon request to the advertising managers of concerns selling technical or engineering products.

William Swindell & Brothers, of Pittsburgh, Pa., have established an electric furnace department under the direction of Frank W. Brooke, late vice-president and chief engineer of the Electric Furnace Construction Company, Philadelphia, Pa. This department offers the latest design in furnaces for melting steel, gray iron and non-ferrous metals, and also a complete line of electric heating furnaces from 30 kw upwards. A license to operate under the Marsh Patents has been granted to this firm.

Whiting Corporation, Harvey, Ill. (Chicago Suburb), has purchased a controlling interest in the Grindle Fuel Equipment Co., manufacturers of Complete Powdered Coal Plants for use in connection with malleable furnaces, annealing ovens, steam boilers, billet heating and various other types of furnaces.

F. J. Ryan & Company, Wesley Building, Philadelphia, Specialists in Industrial Furnace Problems announce the award of a contract from the City of Philadelphia for all of the equipment in the new Forge and Foundry Shops of the Water Department.

Freyn, Brassert & Company, Chicago, have recently shipped boiler and hot blast stove burner equipment to the Rochester & Pittsburgh Coal and Iron Company at Punxsutawney, Pa., and the Chateaugay Ore & Iron Company at Standish, N. Y. The Shenango Furnace Company has recently installed this company's Mathesius hot blast gate valve equipment. Freyn, Brassert & Company have also been retained by the Mitchell-Diggings Iron Company, Cadillac, Mich., in reference to power plant matters.

Bell & Gosset, Chicago, representatives of the Quigley Furnace Specialties Company, 26 Cortlandt street, New York, have been succeeded in that capacity by H. M. Thompson, formerly with the Thomas Moulding Brieg Company, Chicago.

Pittsburgh offices of the R. H. Beaumont Company, Philadelphia, contractor of coal, coke and ash handling systems, are to be moved from 230 Fifth avenue to the Oliver building. Charles W. Ross is the new manager of the Pittsburgh office.

Toronto offices of the International Nickel Company of Canada have been closed and executive business of the company has been transferred to the offices of the International Nickel Company, New York.

New sales offices at Dayton, Ohio, of the Wyckoff Drawn Steel Company, Pittsburgh, are located at 1126 Reibold building in charge of George H. Rehling, who also has charge of the southwestern Ohio territory.

TRADE PUBLICATIONS

The Machine Tool Division of Pawling & Harnischfeger Co., of Milwaukee, has just issued Bulletin 4-F, describing the new Horizontal Boring, Drilling and Milling Machine, which was recently described in detail in this publication. One of the interesting illustrations included in this Bulletin shows how all operating levers are concentrated on the saddle. A circle with 20-inch radius includes all these levers, giving a good idea of the compactness and convenience of operation.

An outline of the fundamental principles of heating and handling, so frequently overlooked in practice, with illustrations of their practical application in the manufacture of wide variety of springs, are carried in Bulletin No. 240—"The Heat-Treatment of Springs with Stationary and Continuous Furnaces,"—published by the W. S. Rockwell Company.

The Electric Furnace Company, manufacturers of the Bailey electric furnace, have issued a descriptive bulletin showing a large number of Bailey installations. It is a very attractive bulletin.

Ingersoll-Rand has published Bulletin 1-R, Surface Condensers, which describes a recent highly important development of this type of condenser and also describes Barometric and Low Level Multi-jet types of condensers, manufactured by the same company. It vividly describes the use of surface condensers.

The Laclede-Christy Clay Products Co. have published a bulletin in which is included an article on "Are Refractories Imposing a Limitation on Stoker Performance?" This article contains worth while information which is of interest to the engineers in charge of plants, particularly those who have charge of the buying of refractories for power plants. A booklet will be sent upon request.

M. H. Treadwell Co. have issued a booklet entitled "Mixer Type Hot Metal Cars." This booklet is descriptive and contains photographs of many of these cars which are now used by prominent steel plants. Among the large users of this type of metal cars are the Cambria Steel Company, who have ten 75-ton cars and Jones and Laughlin Steel Company, who have nine 80-ton cars.

Book No. 113 issued by the Industrial Works, Bay City, Michigan, is descriptive of the Crawling Tractor Cranes. It shows various types of cranes which are used around industrial plants to the best advantage.

The Edge Moor Iron Company has issued a book under the title of "The Development and Theory of the Water Tube Boiler." It is very interesting and covers the subject completely.

Industrial Works, Bay City, Mich., is distributing free upon request Catalog No 113, illustrating and describing the Type BC "Industrial" crawling tractor crane of 20,000 pounds capacity. This crane is preeminently adapted to the needs of road contractors, lumber and coal dealers, gravel, sand and stone producers, foundries, railroad reclamation and storage yards, and moderate size manufacturing plants.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., FEBRUARY, 1922 No. 2

Eastern Steel Company New Blast Furnace

Description of New Furnace Recently Built for This Company at Pottstown, Pa.—A Historical Review of the Activities of the Eastern Steel Company.

By RICHARD PETERS, JR.*

THE Bard of Avon in one of his best known plays used the oft-quoted query. "What's in a name?" The answer to the question as applied to the pig iron industry may be found in the zealous guarding of time-tried brand names of the products of blast furnaces. The earliest iron masters originated the custom of giving personal appellations to their works and the iron made was likewise identified. This practice has been continued to the present time, and while it is true that the more enlightened foundrymen of today lay more stress on the chemical feature of their iron, yet it may be said that they also have great faith in the trade name.

It is therefore of singular interest to know that "Warwick" as a brand has been almost continually used in the eastern district for nearly two centuries, outliving the vicissitudes of time and changing conditions of the industry.

Construction of the original Warwick furnace was started in 1737 and the plant was first operated in the following year. It was located on the south branch of French creek in Chester County, Pa., about 10 miles southwest of Pottstown, where the remains of the furnace are still to be seen. This early plant was probably the largest operating in the colonies and made many castings for the early husbandry. It is credited with having cast the first of the stoves invented by Benjamin Franklin.

In the Revolutionary period the furnace was actively engaged in casting cannon for the Continental army, and during the activities of Howe's troops in the vicinity of Philadelphia some of the Warwick cannon were buried for safety on the furnace property. In the early fall of 1777, before Washington met the British at Brandywine, the American army was encamped for a time at Warwick. The subsequent operations of the furnace are woven into the early history of iron making in Pennsylvania, and the narratives of American manufacture of 60 years ago give prominence to the enterprise at Warwick. It was not until the year 1867 that the furnace made its last blast which was probably due to the increasing difficulties of obtaining charcoal, and also to a great degree in the fact of its inaccessible location with respect to changing methods of manufacture.

Following a successful campaign of over a century and a quarter, it seemed natural when a new iron enterprise was formed in the vicinity that the projectors should seize the opportunity of perpetuating the name of Warwick. Accordingly we find that on March 30, 1872, a charter was granted to the Warwick Iron Company which was headed by Jacob H. Gabel as first president. The actual construction of the new furnace was begun in 1875 and the first blast put on in the following year. The stack, which was built of brick, banded with iron hoops, rested on masonry columns, and its dimensions were 55 feet in height with a bosh diameter of 16 feet. The furnace was blown with six tuyeres, the blast being supplied by a single 96x40 by 7-ft. stroke non-condensing engine, while the air was heated in two iron pipe stoves. The ores used were mainly local and the fuel principally anthracite coal.

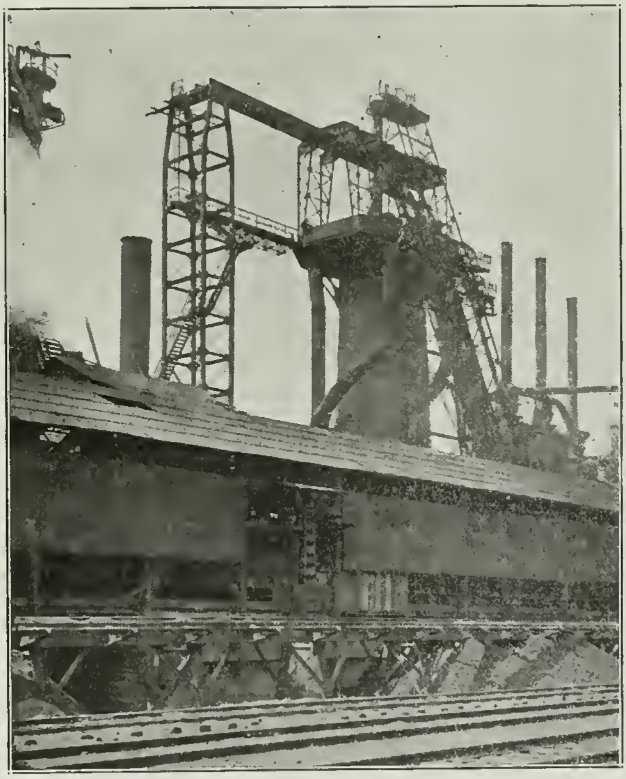

Fig. 1—General view of new blast furnace, showing skip bridge with independent shear leg support.

The starting of the plant was attended with great operating difficulties due to indifferent management, but fortunately for the owners of the property they obtained the services of Edgar S. Cook in 1877. Mr. Cook was at that time in charge of the Monocacy furnace a few miles above Pottstown, and had displayed remarkable ability as a young man in blast furnace practice. Shortly after taking charge at Warwick, Mr. Cook installed a chemical laboratory at the furnace which was one of the first steps in this direction in the east.

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*Mr. Peters is manager of sales of the Pulaski Iron Co.

With the aid of technical advice from the late John Birkinbine, Cook made changes in the lines of the furnace which with other improvements raised the production of iron from 190 to 350 tons per week. From December, 1880, the furnace started on a campaign which lasted five years, the output averaging over 100 tons per day, and under Cook's management the plan proceeded upon a successful career. In 1892, after a careful investigation of fire brick stoves then in use, Mr. Cook installed a set of three Hugh Kennedy type each 20 by 60 feet, replacing the iron stoves of the Durham pattern. This radical change brought forth both friendly criticism and skepticism from the leading anthracite iron masters, who at that tme were stanch adherents of the iron type stove. The new stoves were designed by Hugh Kennedy, then manager of the Isabella plant near Pittsburgh, and from outward appearances resembled the ordinary dome top type of the present, except that they were surmounted by a pair of squatty chimneys which gave them an unusual look.

The revival of the iron business following the long stagnation from the panic of '93 brought forth much expansion in the industry, and the Warwick Company followed the order of the day by reorganizing into the Warwick Iron & Steel Company in the summer of 1899. At this time, at Mr. Cook's suggestion, a new furnace was projected and construction was commenced in 1900. The program included an entire new plant to supplement the existing unit, with the additional feature of the installation of a pig casting machine of the Uehling type. The furnace was 100 by 22 feet with four stoves of the same height, and the stack was the first of that size to be built in the east. The late Edward Cook, who at the time of the rebuilding of the plant was assisting his father, told the writer that the lines of the new furnace were obtained by proportionate enlargement of those of the older stack which had done such good work. It was found in actual practice on the new furnace that these lines did not give the desired results, and several changes had to be made before the furnace gave satisfactory grades and output.

Mr. Cook was an early advocate of machine cast pig iron and did much pioneer work in the introduction of this character of metal into the mixture of those foundrymen who were inclined to be skeptical of the results from changes of long time practices. Not content with his many bold strides toward developing modern methods at a merchant furnace plant, Cook installed a Galey dry-blast system shortly after the results of the experiments at Isabella had been exploited. The Warwick Company had for some 15 years kept complete records showing the amount of water entering the furnaces in the form of aqueous vapor, and concluded if a more regular operation of the furnaces could be maintained the cost of the installation would be justified.

Despite the fact that the Warwick Company now had two stacks, they leased and overhauled the old anvil furnace of the Pottstown Iron Company in 1906 in order to satisfy their market. This lease did not prove to be a profitable one on account of local operating difficulties, and steps were taken to insure the company having available at all times two units. While the original stack had been improved by the replacement of the Hugh Kennedy stoves by those of larger dimensions and of a center combustion type, the company felt that they would be justified in erecting a new furnace to be used as an alternate in the event that either of the two stacks were out of blast. Accordingly a new furnace, known as "A," was constructed of the thin lined type which was located between the two built previously, and arranged to be used with the stove and power equipment of either number one or number two furnace. This unit had the general characteristics of the type much exploited some 10 years ago, and was constructed with the top structure independent from the shell, which was water cooled by means of a spiral trough supplied by the waste water from the tuyeres and bosh plates.

Furnace "A" was practically completed at the time when the Eastern Steel Company made a long time lease on the properties of the Warwick Iron & Steel Company in 1912. With the passing of the management of the properties into other hands the Cooks, father and son, retired from active charge of the furnaces, and their deaths a few years since, closely following each other, removed from the iron world able men with sterling characters.

The Eastern Steel Company, desiring to bring the plant strictly up to date, arranged with the owners of the property for the removal of the original number one stack which had not been operated for some years, agreeing to replace the "A" or center furnace with one of a later type.

The contract for rebuilding the "A" Furnace was placed with Arthur G. McKee & Company of Cleveland, and involved a complete new stack and appurtenances. The hearth level of the furnace was raised 4 ft. 7½ in., the foundation being raised and enlarged to support the new stack. The new hearth jacket is of 1½-in. plate, 22 ft. in diameter and 10 ft. high, allowing a hearth diameter of 15 ft., as compared with 14 ft. in the old furnace. Drawing No. 3827 (Fig. 2) shows the sectional elevation of the furnace, furnace top, skip bridge and stock bins. The tuyere jacket is 19 ft. 6 in. inside diameter, 4 ft. 7 in. high of 1-in. plate. The furnace shell is of ¾-in. plate, the mantle ring being of 1-in. plate and heavy angles.

There are eight columns spaced alternately at 50 deg. and 40 deg. angles. This allows the uniform spacing of the 12 tuyeres, two tuyere stocks being placed in the 50 deg. and one in the 40 deg. space. The columns are of structural shapes these being considered more reliable and less bulky than cast iron columns.

The hearth and bosh cooling system consists of eight rows of copper cooling plates. The experience of the engineers has brought out the inadvisability of cooling plates above the mantle, and the construction of recent furnaces with few exceptions bears this out. The hearth brick are also cooled by cast iron cooling plates inside the hearth jacket. The new lining consists of approximately 497,000 fire brick 9 in. equivalents.

The furnace top was entirely rebuilt. A new platform of 5/16-in. plate with solid hand railing is supported by the cast steel furnace top ring and structural brackets. The top structure is notable in that it combines all facilities of a modern furnace top with a compactness and co-relation of parts which is not often realized. The three structural "A" frames supporting the trolley beams are mounted on the platform, two of these forming a tower.

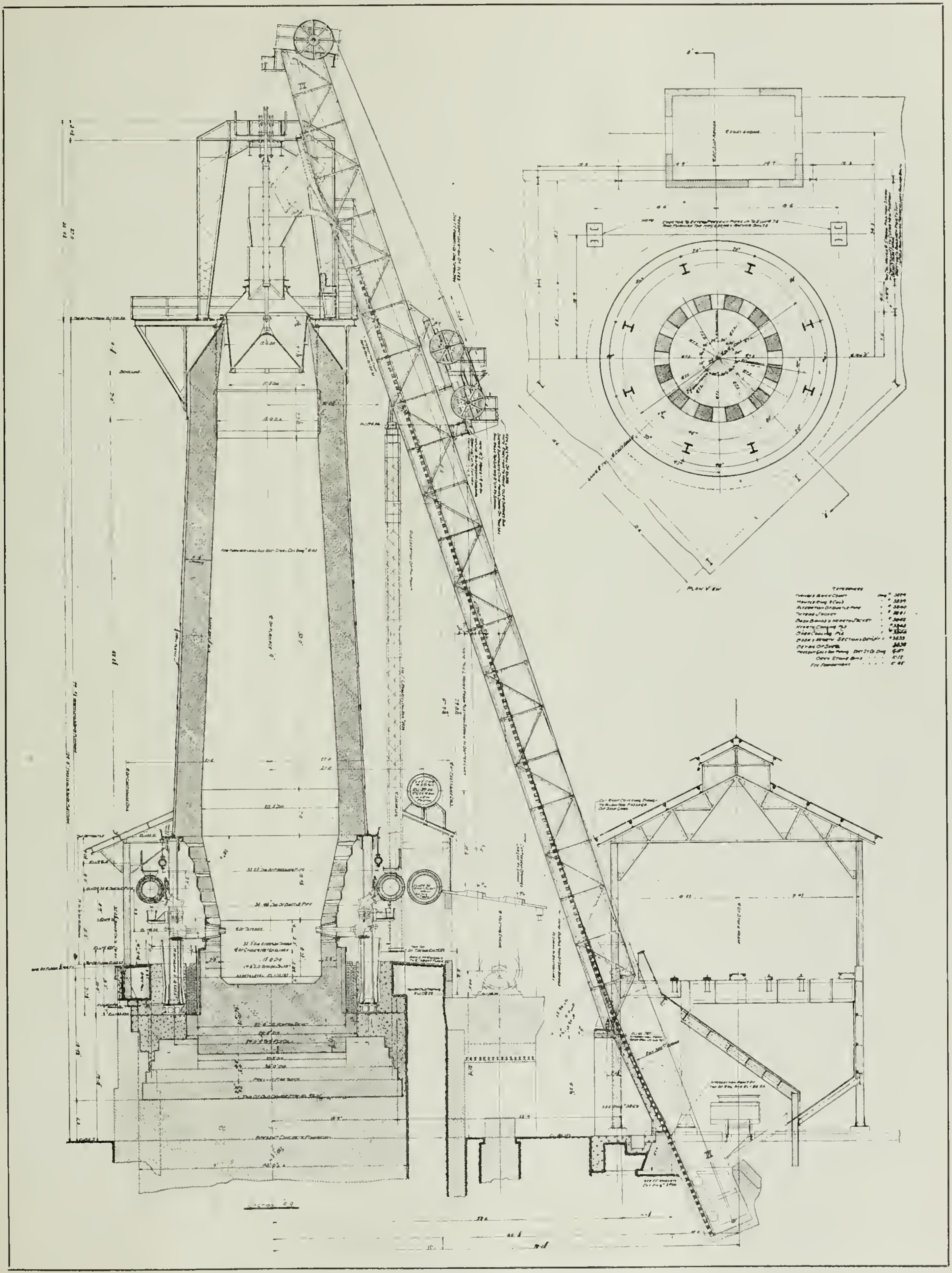

Fig. 2—Cross section through new furnace.

A novel scheme was developed to utilize the old vertical hoist tower of the furnace. This was rebuilt and equipped with stairway and platform and so placed as to support the ends of the trolley beams, thus allowing them to extend to the unusual distance of 68 feet from the center line of the furnace. The trolley has a capacity of 25 tons, sufficient to handle the load of the large bell and hopper taken together.

The large and small bell beams, as shown in the drawing, are supported by the trolley beams, and are pivoted on a single forged steel shaft with special adjustable bearings. The large beam only is counterweighted, the additional counterweights being provided at the bell cylinders which are placed at the cast house level. The bell beams are connected with the bell cylinders such that the bells open by gravity.

The skip bridge was raised to conform with the new furnace height and the angle steepened from 67 deg. to 71 deg. 47 min. with the horizontal. The bridge is supported by a shear leg independent of the furnace stack, and has a plate deck under the rails. At the top of the bridge is an auxiliary trolley beam form handling the bell beams. The hoist house is under the skip bridge and the skip ropes brought through the bridge by guide sheaves as shown in the drawing.

The new large bell is of cast steel 11 ft. 3 in. in diameter with 50 deg. slope. The large bell rod is forged steel 5 in. in diameter. The stock distribution is accomplished by a McKee revolving distributor, equipped for automatic recurrence of a six skip, six position cycle.

Four new downcomers were provided, connecting to the old pipes. The downcomer connections at the top of the furnace are of the McKee patented type and are made up of cast steel. These downcomers serve as a preliminary dustcatcher in that the gas must turn at a sharp angle in order to pass the baffle and enter the vertical outlet, thus causing the particles of stock carried with the gas to strike the end of the inclined pipe, or the baffle casting, and roll back into the furnace. The arrangement of downcomer castings is shown in Fig. 1. One bleeder 36 in. in diameter by 41 ft. high was installed.

Three 75-ton hot metal ladle cars were purchased and put in operation. These are of the mixer type and are motor operated.

All of the engineering and reconstruction work was done by Arthur G. McKee & Company on a lump sum contract. The supervision of the design and construction was handled for the owners by S. O. Hobart, manager, and his assistants.

Disintegration of Blast Furnace Linings

We Invite Discussion of This Subject Through The Blast Furnace and Steel Plant—Brick Makers Should Make Experimental Tests to Find Resistance of Various Makes of Brick to Zinc Fumes

By P. O. MENKE*
General Supt., Shenango Furnace Co., Sharpsville, Pa.

WITHIN recent years the blast furnace men have become more or less alarmed over the repeated failures of blast furnace linings. The first few failures were confined to a certain well known brand of steam pressed brick. Shortly afterward we heard of other well known and popular makes of furnace linings giving out. All of these early failures were confined to steam pressed linings, but later there has been found disintegration in some well known hand made linings. The probable reason that the failures have not been more numerous in the hand made brick is on account of the popularity of steam pressed linings in recent years.

There is no doubt that the quality of most of the popular brands of fire brick has greatly deteriorated during the last five or six years, principally due to careless and inefficient labor, over which the maker had no control, but some of this is probably also due to mixing in some inferior clays. The proportion of plastic clay was increased beyond the former usual ratio. The flint clays were ground finer in order to make a nice looking brick; in fact, most of the furnace men in recent years have laid too much stress on getting a smooth, nice looking fire brick that would lay up nicely, with minimum cutting and labor. Nevertheless, all of the aforesaid changes should not account for all of the trouble.

During the early part of this year, while visiting a large eastern plant, my attention was drawn to some shell failures. Some of these were on light shells, but one of these cracked shells was built out of 1-inch plate, well riveted and butt strapped, in every way a first class job. It had a steam pressed lining laid against the shell without any packing space. This shell had started to split vertically several sheets above the mantle. At the time this was attributed to the probable expansion of the steam pressed brick. I was alarmed, due to the fact that we have been laying our steam pressed linings against the shell for some years past, first on one of our furnaces which had a 1-inch shell, afterward on a furnace with a ¾-inch shell and two furnaces that had ½-inch shells. These furnaces have been operating that way for seven years or more, and as yet show no signs of rupturing the shell.

On looking over the aforementioned shell, I noticed some secretion at the point of fracture which looked like a deposition of zinc fumes. It struck me at once that this might be a case of zinc impregnation of brick work. I suggested having the secretion analyzed for zinc, in addition to taking a drilling through the crack and having some of this brick material analyzed. We have heard later that zinc was found.

Also found that it was no uncommon occurrence to burst furnace shells in that part of the state; in fact, it was such a regular thing at one plant that it led to the design of a very ingenious banding lug for banding shells whenever they showed signs of giving way. Shortly afterward, we read and heard of a very bad shell failure with fatal results, which was generally attributed to an explosion. As this mishap was so unusual and of such fatal consequence, it had most all of the furnace men alarmed who heard of it.

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*Paper read before The Eastern States Blast Furnace and Coke Oven Association.

On a visit shortly after and on seeing photographs of this wreck, it seemed to me I could see action of zinc impregnation and disintegration. The manager assured me there was no zinc, as he did not use any zinc bearing raw material. On examining this furnace we found a distinct vertical separation and cleavage of the remaining portion of the inwall. Although we could not detect any metallic zinc, I was quite sure I could see particles of zinc oxide in this cleavage. On some of this brick material being analyzed later, zinc was found in the form of oxide, chloride and metallic, as high as 40 per cent down to .15 per cent.

With zinc impregnation as high as shown in the aforegoing analysis it does not seem unreasonable at all, knowing the terrific strain that a zinc saturated lining exerts, to have split this shell, particularly so as it was water cooled. I believe that this shell also had a splash jacket which prevented the operators from promptly detecting any signs of splitting of the furnace shell under the splash jacket. With the split shell it would not necessarily take a very heavy slip to put on enough additional strain to tear horizontally and open up.

We shoveled out some furnaces that had been banked for several months. On examining linings, we found one of them had a considerable belly, extending from the mantle to 30 feet above the mantle, reaching less than one-third of the way around the furnace. On digging in to get a footing for a patch we found the brick wall glazed and hard for a depth of from 4 to 1 inches back of the inner face of the lining. Beyond that, we found a zone of separation and spalled cleavage for a distance of from ¼ inch to 2 inches. This space was filled with zinc oxide, metallic zinc and large carbon deposits; zinc from 2 to 20 per cent. Beyond that, for a distance of from 2 to 4 inches, the brick was disintegrated and crumbly, saturated to the extent of from .03 to 6.28 per cent of Zn. Beyond that point, extending to the shell, the brick was firm and in a good state of preservation, with practically no zinc impregnation. The balance of the lining seemed very good. It had worn back less than 2 inches of the original dimensions.

We cut two test holes through the good lining back to the shell, opposite the bad place. Found no disintegration. The face of the brick was glazed and firm, and really harder than it would be in the original state. Found metallic zinc in the joints, also some oxide of zinc about 12 inches back from inner face of lining, but this had in no way penetrated the brick.

As we have had some spray cooling on outside of shell on the thin spot of this furnace, we laid the disintegration at this point to this cooling effect. This furnace was lined up with the same make of steam pressed brick that had given us over 800,000 tons the preceding blast, and was in good serviceable condition when blown out.

On finding this condition at this furnace we cut some test holes above the mantle at our other furnace that had been lined up with the hand made brick of a popular make. This lining had been stored in our brick shed over five years, so must have been made at a time before we heard much of disintegration of furnace linings. We found the inner face well glazed and firm for a distance of about 4 inches. From there on we found zinc, both metallic and oxide, and disintegration to the extent of making the brick soft and very easy to cut, to within 4 or 5 inches of the shell. The conditions were identical at the two opposite points of the furnace. We made no repairs, but plugged the holes, and this furnace is operating today.

On the strength of these observations closer investigation in our district of some of the most prominent cases of disintegration was made. We found in one particular case where they had lost two linings that they had found zinc up to 18 per cent in this brick. Considerable of this was metallic, but they did not seem to blame the presence of this zinc for the disintegration of their linings.

Our own experience in this matter has been expensive, and the cause of great delay. Nine or ten years ago, on account of low phosphorus contents, our furnaces had used a proportion of Blue Billy agglomerates in our burden. First split one shell on the smaller furnace which had seen considerable service. This shell had to be renewed. Within two years our larger, newer furnace opened up her shell both in the vertical and horizontal seams, in the heavy section. We promptly banded this furnace. She burst these bands until we put on 12x1½-in. bands, very closely spaced. After that, sheared the horizontal seams of the shell, and showed swellings and distortions on the side of the furnace. This furnace was excessively water cooled in the bosh. Also had cooling plates above the mantle. Most of the trouble and breaks in shell took place in the cooled zone. We had more or less metallic zinc around the bosh plates most of the time.

We found it necessary to put this furnace out for renewal of stack. Did not get a chance to blow this furnace down more than 35 feet, as the furnace shook so badly as to make it unsafe. On taking this lining out we found the most complete disintegration we had ever seen. It was not burned out in any way, but had the full thickness of the lining, in addition to some scabs on the inside. It was not necessary to use any picks or steel bars, but the lining was shoveled out. The full outlines of the brick and joints were visible until we got to the water cooled portion, where the zinc showed up, mostly in the metallic form, due to the water cooling.

On taking analysis of this lining we found up to 49.86 per cent Zn and up to 40 per cent in the scab and scaffold. In fact, lining and scab were so rich in zinc that it was sold to a chemical company for the recovery of the zinc. A considerable portion above the water cooled section was in the form of chloride of zinc

On finding this condition we put up a 1-inch shell, discontinued the cooling above the mantle, also reduced the cooling below the mantle, and cut out Blue Billy agglomerates and other zinc bearing material. Put in a steam pressed lining laid tight against the shell, and followed the same practice on our other furnaces with the lighter shells. Our results so far have been satisfactory, until we ran into zinc recently. Feel we would not have run into any difficulties even then if we could have kept furnaces running. Banking, shoveling out and cooling largely aggravates this condition.

It might be well to give a brief outline of the action of the zinc in the furnace. Being charged into the top as zinc oxide, finely disseminated through the ore, it descends unchanged to the fusion zone, as the reduction temperature is 1,000 deg. C. and over. The zinc oxide is reduced by solid carbon to metallic zinc; liberated as vapor, it ascends with the gases to the cooler zones. The zinc is re-oxidized through the temperatures from 1,000 deg. to about 500 deg. C. to the reaction $Zn + CO_2 = ZnO + CO$ and is carried up by the gases as zinc oxide. The larger portion passes out into the stoves, dust catcher, boilers or into the atmosphere. A portion redeposits on the descending stock to repeat the before-mentioned cycle of changes.

Some of the zinc vapor is absorbed by the lining up to as high as 50 per cent. It usually shows up as small yellow crystals. Sometimes it is found with carbon deposits in the disintegrated and laminated portions of the lining. Some of this zinc shows up in the metallic form. It usually is around the water cooled part of the furnace, also in the part of the lining that is not water cooled but had a chance to cool down after banking or blow out.

In scabs that adhere to the water cooled portion of the furnace, it probably combines with the alumina, forming zinc spinel, which is practically irreducible, as these scabs are mostly still present and intact after the furnace has been blown out. It is also generally assumed that the zinc oxide combines with the alumina in the fire brick. As the coefficient of linear expansion of zinc is like 60 to 1, compared to silica, which is the principal constituent in fire brick and is about 3 to 1 compared to steel, it can readily be seen that it would not take a great deal of impregnation to destroy the bond of the brick and exert great expansive stresses. The hand made brick, on account of its greater porosity, has a tendency to take up more of this element than the steam pressed.

Most of the Blue Billy agglomerates carry zinc, which can easily be guarded against, but as some limestones carry traces of zinc, also some of the Lake Superior ores, it makes it rather hard to be absolutely sure there is no zinc bearing material charged into the blast furnace. No matter how low the percentage of zinc is in the raw material, on account of its being accumulative, it will eventually show up.

We cannot see why it should in any way be detrimental to lay a lining against the shell without packing space, and particularly so with steam pressed brick which is a good conductor of heat and warms up the shell to a point where it can expand with the brick work, as most blast furnace lining brick should be somewhere near neutral and not subject to a great deal of expansion under heat.

We feel by using a heavy shell (if necessary above 1 inch thick) and cutting out the water cooling above the mantle will cut down the trouble to a minimum. It might also be well for the fire brick makers to make experimental tests to find the resistance of the various makes of brick to zinc fumes.

Otis Steel Company Completes the Erection of a Modern Sheet Mill Department

Features of the New Department Which Is Located at the Company's Riverside Works Are Extra Heavy Mills, Powdered Coal Fuel, Continuous Pair Furnaces and Electric Drive.

By DONALD N. WATKINS.

THE Otis Steel Company of Cleveland Ohio, have added to their present equipment by the erection of a most modern and up-to-date sheet mill department. The new mill is equipped with all modern improvements. This department is located at the Riverside plant in the center of Cleveland. The more important installations in the new plant include extra heavy mills, electric drives, powdered coal fuel, continuous pair furnaces, electric furnace chargers, Baird water cooled floors and other essential equipment.

The hot mills are housed in a steel building 456 ft. long and 90 ft. wide. Running parallel and connected to this building is a bar storage building 456 ft. long and 75 ft. wide. The lean-to over the furnace is 456 ft. long and 26 ft. wide, while the shear building is 456 ft. long and 40 ft. wide. Continuous to the main mill building is the annealing building, 500 ft. long and 80 ft. wide, with a lean-to 340 ft. long and 31 ft. wide. The pickler building is 140 ft. long and 50 ft. wide, while the warehouse is 380 ft. long and 75 ft. wide and has a lean-to over the shipping tracks 380 ft. long and 16 ft. wide. The buildings are of steel construction and are fitted throughout with Lupton steel sash. Kiefer Sheeting & Painting Company of Pittsburgh put on the sheeting and painted the building. Wood block floors are installed in the pickling and warehouse buildings, while the other floors throughout are of brick.

Special attention has been given to ventilation and good lighting. The main mill buildings are constructed so as to give the best natural lighting.

The sheet mills were built by Mackintosh-Hemphill Company, Pittsburgh, Pa., and consist of eight mills having rolls 30 in. in diameter, and comprising one finishing stand and one roughing stand per mill, thus making a total of 16 stands in the layout.

There are six jump roughing stands with rolls 30x48 in. and six finishing stands with rolls 30x44 in. There are also two balanced roughing stands with rolls 30x54 in., and two finishing stands with rolls 30x54 in.

The mills are driven by two separate motor drives, through suitable gear reductions, and are so arranged that two mills are driven on each side of each motor drive. The mills are of heavy rugged design, the housings being made of cast iron.

Four drag units are provided at the end of each group of two mills and are of the standard Mackintosh-

Hemphill spring type. The balanced roughing stands have motor driven screw downs and the top rolls are balanced by counterweights, underneath the shoes.

One feature with regard to the arrangement of the counterweights is of interest in that the weights are *not* held between the shoes and parallel with them but extend to the side of the mill at right angles to the shoes, which makes it possible to attach a crane to the counterweights and block same up by simply removing a floor plate. A pinion stand of standard design is provided between the two roughing stands for driving the top rolls of the same.

The hot mills are driven through a Falk gear drive with about 8 to 1 reduction and the mills are arranged half on each side of the drive which consists of a 1,000-hp. Allis-Chalmers motor of 2,200 volts, three phase, 25 cycle, 250 rpm.

The electric power is furnished from the company's own power house.

The drive is of the usual Falk construction, consisting of single reduction gears.

The hot mill furnaces were all designed and erected, complete, by the George J. Hagan Company, Pittsburgh, Pa. Fig. 3 gives a front view of the sheet furnaces. Each sheet furnace is of the double compartment type, with center partition wall, and are known as the solid hearth type. The interior area of these furnaces is such as to give the highest working efficiency without any danger of burning the edges of packs when the sheets are in the furnace on edge The furnaces are specially designed with large flue areas so as to take care of any excess dust or accumulation that may be caused by the use of powdered coal as fuel. All flues are made easily

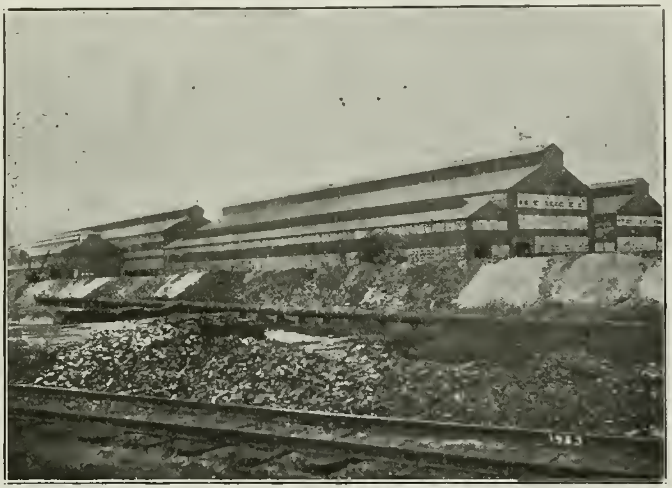

Fig. 1—General view of sheet mill buildings—Southeast elevation.

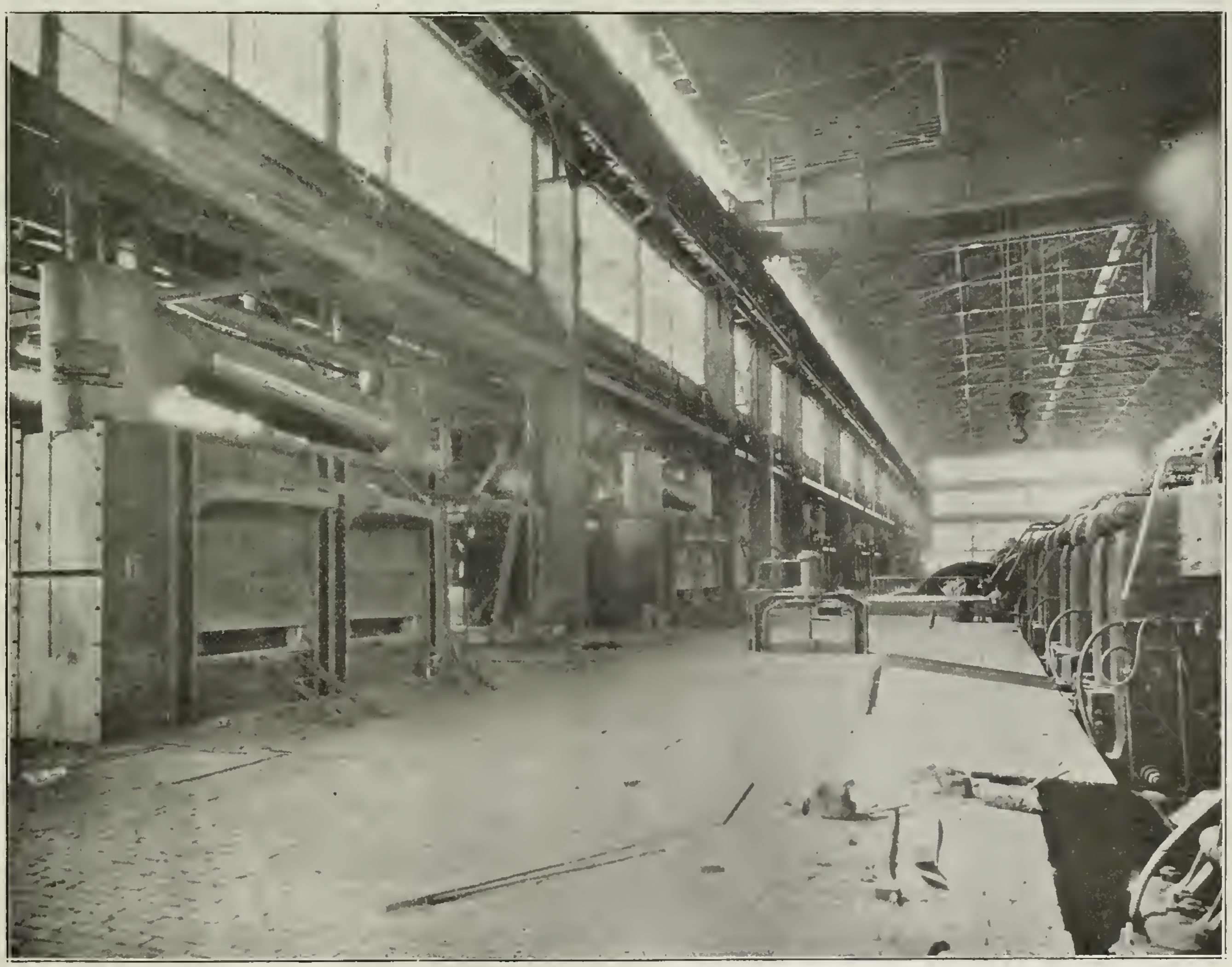

Fig. 2—General interior view of sheet mill building showing mill train.

accessible and very simple arrangements made for cleaning same. The furnaces are all heavily incased with steel plates and castings. There is no brickwork exposed

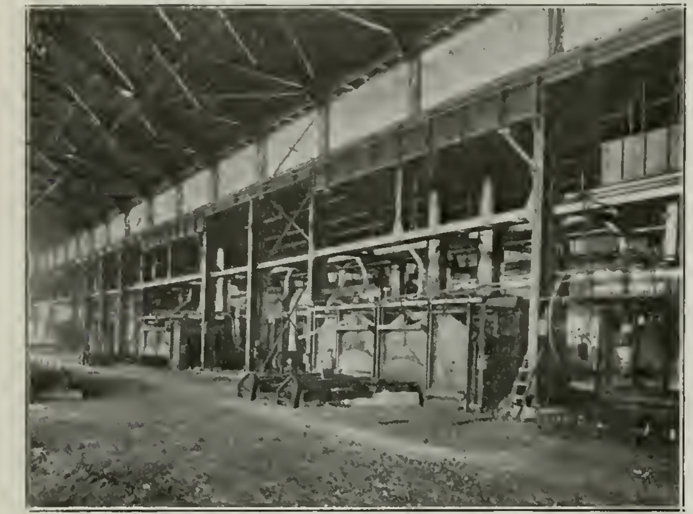

Fig. 3—General view of sheet and pair furnaces, mill side—in mill building.

The sheet furnaces are located approximately 27 feet from the face of doors to the center of hot mill.

Fig. 4 gives a rear view of the Hagan-Allis patented continuous pair furnaces. This photograph shows the very simple electric charging machine which is under the control of the heater at all times. The pair furnaces are built double, that is, with one common binding between each furnace and each furnace is entirely independent of the one adjacent. Independent combustion chambers are used and independent stacks are usel. An electric crane travels the full length of the building from the rear of these furnaces, thus eliminating all overhead travel on standing, which is customary in other mills. The cut bars are all handled by the crane at the rear of these furnaces and stacked adjacent to the charging machine. When charging these furnaces, the operators are not exposed to any direct radiant heat as the doors are never opened until after the charging machine has been stacked with bars. When the cold heat is ready to be charged, the rear door is opened and the push button control of the charger automatically charges the new heat into the furnace and advances the next heat forward to the front of the furnace ready for rolling. By this particular type of furnace there is no extra handling of the bars such as is customary by piling in the old type furnaces. Each and every bar is advanced through the same heat zones, automatically heating the bars absolutely uniform and without scaling. This furnace was adopted for its superior qualities of heating and from the fact that tonnages can be maintained in the hot summer months the same as in winter months, due to the elimination of manual effort as the heater simply draws the bars from the furnace to the standing of hot mill. The pair furnaces are located within a few feet of the front line of the sheet furnaces and the drag of bars from furnace to hot mill is short, thus giving a superior working condition over those found in other plants as a rule. These pair furnaces are of the solid hearth construction, having no return flues or circulation below hearth, thus assuring no loss of heat transmission, which is customary in the old type furnaces. The metallic hearths which are used in these furnaces are made by the Hagan Foundry Corporation, Orrville. Ohio, of special refractory or heat resisting iron. There are three double pair furnaces, designed for 12x50 in. maximum bars, thus allowing one pair furnace and one double sheet furnace for each mill. Six of the sheet furnaces have door clearance of 56 in. and two have door clearance of 62 in., which makes it possible to heat the maximum widths of sheets in these furnaces.

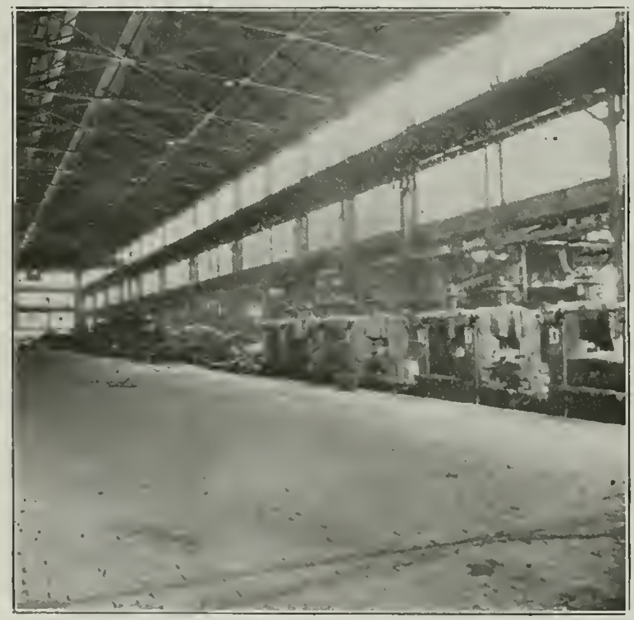

Fig. 4—General view of sheet and pair furnaces, charging side—in bar storage building.

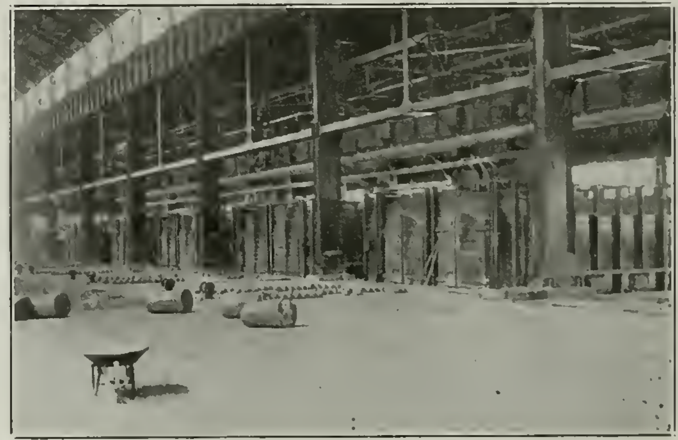

Fig. 5—View of annealing ovens in new sheet mill.

All furnaces are designed for maximum commercial tonnages that it is possible to turn out in sheet mill practice.

Fig. 5 gives a front view of the box annealing furnaces. These furnaces were all designed and constructed complete by the George J. Hagan Company, Pittsburgh, Pa. There are six double compartment, double length, annealing furnaces, giving ample spares and ample capacity for this plant. These furnaces are known as the heavy duty type furnaces. They are entirely bound with steel and castings, and are designed with extra heavy walls, which assures very low furnace loss. Each compartment of these furnaces is entirely independent of the compartment adjacent. The combustion chamber is independent and the control draft is independent. Thus, one side of the furnace can be operating while the other side is idle. The balls and tracks of the annealing furnaces are made of Hagan refractory iron, furnished by the Hagan Foundry Corporation, Orrville, Ohio.

One of the most interesting features of this mill is the pulverized coal installation, which was supplied by the Quigley Furnace Specialties Company and provides powdered coal for sheet and pair and annealing furnaces.

The pulverizing plant is located about 100 ft. from the main buildings and at the extreme end of the annealing department building, which is located adjacent to and in line with the hot mill building. The pulverizing plant comprises a plate steel track hopper with reciprocating feeder attached to the discharge opening. The coal is delivered in hopper bottom cars to the track hopper, and after passing through a single roll coal crusher, is elevated by means of a chain and bucket elevator and delivered to a belt conveyor, equipped with magnetic separator pulley for the removal of any tramp iron. The coal is discharged into a 50-ton plate steel crushed coal bin, which is supported by structural steel framework above the firing end of the dryer. A regulating gate and worm feed screw control the feed of coal into a Ruggles-Coles dryer, having a capacity of 5 tons per hour. The coal on leaving the dryer is raised by a chain and bucket elevator and discharged into a 3-ton dried coal bin of plate steel. It is fed from this bin to a 5-roller low side Raymond mill, which pulverizes the coal and after finishing same removes the finished product by air suction, and deposits it into the powdered coal hopper of the compressed air transport unit. The hopper is supported by structural steel framework directly above a blow tank, which consists of a steel shell with suitable coal inlet valve, weighing scale, and compressed air controlled valves for admitting compressed air into the tank. A shut-off valve in the 4-in. transport line permits the building up of pressure in the blowing tank to the necessary pressure for delivering the coal to any point desired in the mill. A single stage air compressor, motor driven, with suitable air receiver, etc., is included in the equipment to supply the compressed air for the transporting of the coal. The 4-in. transport line on leaving the milling plant crosses over, as is shown by the photograph, to the annealing department Three powdered coal hoppers retain the necessary powdered coal to supply the furnaces. To the bottom of these hoppers are attached four powdered coal feeders, all driven in multiple by one motor. Each annealing furnace has but one burner for each chamber, and the coal is fed by an individual feeder through a small wrought pipe at about 6-oz. air pressure, which delivers it to the combustion chamber of the furnace, through the center of the burner. The remainder of the air required for combustion is supplied by low pressure fans at about 1¼-oz. pressure. The feeders are so arranged that all can be driven simultaneously or any one or more stopped. This is done by suitable clutch control mechanism. Switching valves of special design for the service are inserted in the 4-in. transport line, and divert the coal as required for the various powdered coal hoppers in this department as well as in the hot mills. A small Cyclone collector is provided on each bin for the venting of the small amount of compressed air used in the transport of coal. This absolutel yeliminates the possibility of pressure being applied to the bins.

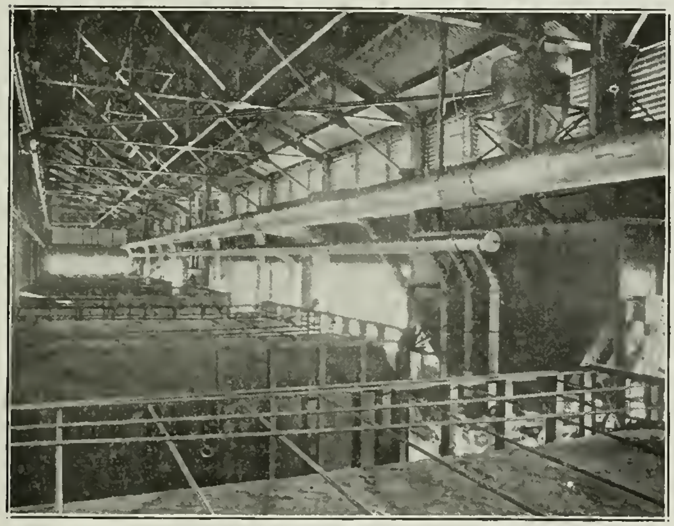

Fig. 6—View over top of annealing furnaces. In the right-hand foreground will be seen a powdered coal hopper, cyclone collector and transport line, together with the vent pipes to the outside of the building. The primary and secondary blast lines are clearly shown.

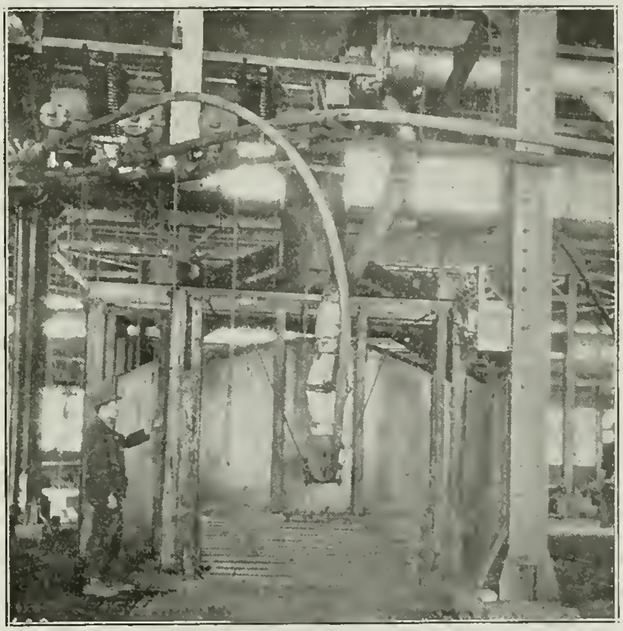

Fig. 7—Rear view of sheet mill furnace showing burner, coal and air pipes from feeders to burners, controllers attached to bottom of powdered coal hopper and etc.

Upon leaving the annealing department, the coal transport line passes into the hot mill building, where it is supported from the crane girders.

A feature of this installation is the fact that throughout the annealing department and hot mill all equipment is operated from the mill floor.

The salient feature of the entire installation is its cleanliness. The milling plant is entirely free from powdered coal in suspension, and the same is true of the mill buildings. The building for housing the coal pulverizing equipment is of structural steel with corrugated iron siding and roofing, liberally supplied with windows and ventilation; the floor of this building is of concrete.

The hot mill standings on the furnace side of the mill are of the Baird water cooler type. These were furnished by the National Roll & Foundry Company.

There are five stands of cold rolls located in the annealing building. These have 28-in. rolls. Two of the cold rolls and their drive, which were transferred from another section of the plant, were supplied by the Fawcus Machine Company, Pittsburgh. Three others, made by the Otis Company, make up the train. These are driven by a 200-hp. motor.

There are four 156-in. squaring shears located back of the finishing mills in the hot mill building. These shears, which are driven by 15-hp. motors, were supplied by the Erie Foundry Company of Erie. Located also in this building is a hydraulic snap bailer supplied by the Galland-Henning Manufacturing Company, Milwaukee.

The pickling department is equipped with two Mesta four arm steam operated automatic pickling machines. The Otis Company have designed and installed a special coke fired drying machine for drying high finished sheets after pickling. The operation of this machine is to pass the sheets between rubber rolls onto a motor operated conveyor that carries them on through the drying chamber, which is about 18 ft. long.

As stated before, the warehouse department is located in a large, well lighted building 380 ft. long and 75 ft. wide. Special equipment installed in this department consists of two Erie Foundry Company 156-in. squaring shears, two Walker & Elliot and a Hillis & Jones roller leveler, one Otis Company oiling machine, a Streine corrugating machine, a Globe Foundry & Machine Company patent leveling and stretching machine, a painting machine, one Standard and one Fairbanks bundling scale and a Fairbanks beam registering scale. Sheets are hauled to the warehouse on roller bearing trucks built by the Ohio Galvanizing & Equipment Company by Lakewood Engineering tractors.

The crane equipment installed in the new plant consists of five Cleveland cranes ranging in size from 10-ton to 40-ton and one Alliance 40-ton crane. All the electric motors used in the plant outside of the two mill motors were furnished by the General Electric Company.

Throughout the entire designing and constructing of the plant, the safety and welfare of the workmen were provided for. All machinery was properly safeguarded when erected. Shower baths, lavatories, lockers and other modern conveniences will be provided for in a separate building that is to be constructed.

The construction of the plant, with the exception of the erection of the buildings and furnaces, was done by the Otis Company under the supervision of its mechanical and construction departments. The buildings were designed by the American Bridge Company in connection with the engineers of the Otis Company and were erected by the bridge company.

Developments in By-Product Coking

Prevention of Lime Deposits in Ammonia Stills—A New Plant Described Which Overcomes Many Difficulties Formerly Encountered, and in Addition Affords Excellent Heat Economy.

By A. THAU

PART I

THE ammonia liquor recovered on by-product plants holds the ammonia, outside of comparatively small amounts of free ammonia, in the form of salts in solution which, according to their inclination to decompose and liberate the ammonia, can be classed in three groups: First, salts which break up at normal temperature; second, salts which are decomposed by the influence of heat, and third, salts resisting high temperatures and decomposing only by chemical reactions under the influence of alkalies added. Corresponding with this behavior of the ammonia compounds in the liquor, the stills consist of three different parts, viz., one in which the free ammonia and the salts mentioned under 1 and 2 are subjected to high temperature, and the ammonia together with the acids liberated are at the same time expelled. The acids volatilized consist principally of carbon dioxide, sulphuretted hydrogen and hydrocyanic acid.

The liquor freed from the easily volatilized ammonia compounds retains only those salts in solution which are mentioned as the third group to decompose under the influence of alkalies. The liquor runs from the upper part of the still into a chamber in which it is mixed with milk of lime and overflowing from this chamber, the liquor holds only free ammonia in solution which is driven off by the heat in the third part of the still. Very few American plants and none in Europe apply soda lye instead of lime, as the former, though much cleaner in operation, is generally too expensive for the purpose.

The operating of an ammonia still is under certain circumstances an expensive and uncertain operation because of the fact that by lime deposits and obstructing an inner passage for the liquor, the whole still may be suddenly thrown out of work. The reasons for the depositing of solid lime inside the still are two fold and must be attributed to either a mechanical cause or a chemical action, generally to both.

The treatment of the lime before being introduced into the lime chamber of the still varies in most plants. In the majority of cases the lime is slaked immediately with a great excess of water after its arrival, agitated with a scraper and passed through fine meshed screens into a large square pit in which the lime settles while the water drains gradually through the brickwork, so that the slaked lime remains in form of a thick paste which can be handled by a spade. In this condition it is according to requirements transferred to the stirrer tank of the lime feed pump and by means of a hose pipe quenched through a screen on top.

On other plants, particularly in England, the lime is not slaked in bulk, but stored in the same condition in which it arrives. A certain required amount is placed in a box screen which is partly submerged in the water of the stirrer tank of the lime feed pump. The lime is so slaked and transformed into milk of lime without a preliminary treatment. Though these latter means of preparing the milk of lime may appear simpler and cheaper, it does not pay in the long run since calcined lime cannot for this purpose be stored any length of time in the open owing to its hygroscopic nature and because it deteriorates rapidly, losing much of its active properties. Such deteriorated lime will not dissolve to very fine particles and while the condition of the milk of lime should as near as possible approach that of a colloidal solution, the rough particles of the deteriorated lime have a tendency to settle out and deposit as soon as the velocity of the liquid increases. It does pay to take some pains in the preparation of the milk of lime in order to avoid trouble in the still, where poor lime causes obstructions.

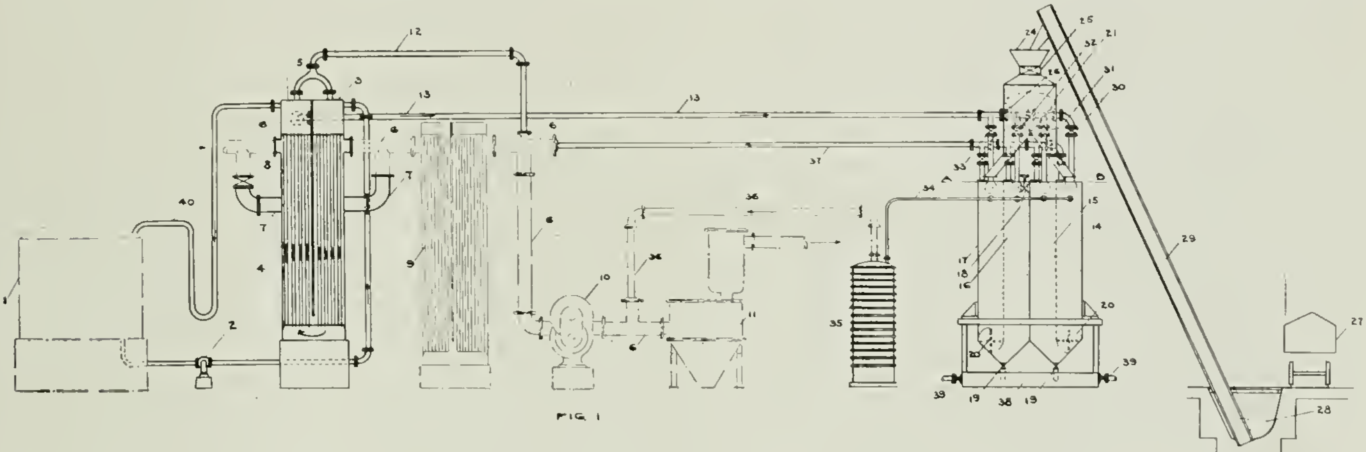

FIG. 1

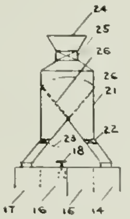

FIG. 2

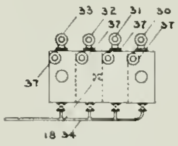

FIG. 3

The lime chamber of the still, in which milk of lime and ammonia liquor are mixed and brought in intimate contact with each other, is generally of great capacity and though steam is blown into it through a rose or perforated coil from the bottom, an even agitation over its whole area cannot be produced and some solid lime is sure to settle out on the sides and the bottom, particularly during the time the still is not operated. It is difficult to maintain the milk of lime at an even density and feed in exact requirements to the volume of the liquor. To be on the safe side, the stills are generally worked so that a small excess of solid lime is noticeable in the waste liquor leaving the still. If the density of the milk of lime is too great, or the feed too strong, an excess of solid lime will settle out in the third part of the still. This leads to a reduced efficiency and eventually to obstructions, throwing the still out of work altogether.

While this explains the mechanical depositing of solid lime, chemical reactions cause the formation of unsoluble lime compounds if the already mentioned volatile acids are not driven off with the free ammonia in the first part of the still. With carbon dioxide the lime forms calcium carbonate, with sulphuretted hydrogen, calcium sulphate (gypsum) and with hydrocyanic acid, calcium cyanide, of which compounds the former two are not soluble in water and very difficult to remove from the still, particularly if other mechanical impurities such as solid lime particles and pitch form a mixture with them. Though tar and lime have no inclination to enter into mechanical combination, the light oils of the tar are evaporated in the still and a soft pitch remains which, covering the bottoms of the still sections and taking a coat of solid lime on top, forms an effective isolating medium preventing the heat from penetrating the iron plate of the bottoms.

To prevent the lime from depositing inside the stills, a number of precautions should be carefully observed. The liquor should be free from mechanical impurities, particularly from tar. The feed and the steam admitted should be in such proportion that the free acids are completely driven off in the top sections and do not enter the lime chamber to form unsoluble compounds. The milk of lime should be free from solid lumps and of proper density. If too thick, solid particles will settle out easily; if too thin a great waste of steam must be accounted for to heat the correspondingly greater amounts of milk of lime to the boiling point.

In the designs of the stills efforts are made to enable an easy cleaning of the stills or to prevent the depositing of solid lime altogether. A new still has recently been introduced in which every tray can be drained from time to time by means of valves accessible from outside for the purpose of cleaning the trays.

Still more effective are stills with revolving trays inside. They are built similar to the centrifugal gas washers, but rotate quite slowly to prevent solid lime from settling. There are two sets of trays arranged alternatively, one fixed to a vertical central shaft and revolving with it, the liquor overflowing on the periphery of the trays. The intermediate trays are fixed on their periphery to the inner shell of the still while the overflow of each is arranged in its center, allowing the shaft to pass through it. A great number of such trays give in this way the down flowing liquor mixed with milk of lime and the rising steam a long passage in zigzag way and counter current through the still. To prevent solid lime from depositing on the inner surfaces of the still, a number of steel scrapers are arranged inside in such a manner that the rotating trays are passing between fixed scrapers while the fixed trays and the inner shell of the column are kept clean by scrapers fixed to the central shaft and rotating with it. The shell is provided with hand holes through which the scrapers can be adjusted or exchanged. A number of such stills have made their appearance in ammonia works of German coking plants in recent years and are giving satisfaction because a periodical cleaning is not required now. Their upkeep and power consumption are naturally somewhat higher than with the ordinary stationary still while the units are also larger for a given output.

A new plant* has recently been tried on a small scale eliminating all the aforementioned difficulties and after various alterations, which are embodied in the sketches shown, giving entire satisfaction. Fig. 1 shows diagrammatically a typical by-product plant with the new arrangement included. The apparatus of the plant is only taken into consideration as far as the ammonia recovery is concerned and only that apparatus which serves the present arrangement are drawn in full lines, the other parts shown in dotted lines, are only added to make the whole plant easier understood. Figs. 2 and 3 are detail views of the plant.

The crude ammonia liquor collected at the by-product plant is decanted from the tar and stored in tank (1). From this it is drawn by means of the pump (2) and forced into the compartment (3) of a high level tank resting upon a heat exchanger (4). The latter is shown as an ordinary gas cooler with vertical tubes which in this case must be made entirely of cast iron. For this reason it might be more convenient to use a cooler with a great plurality of horizontal tubes which are shorter and easier to handle in erecting and can be made with thinner walls. In a heat exchanger as shown in Fig. 1 the liquor runs downwards from the compartment (3) through the vertical tubes directly underneath and passing through a bottom chamber travels upwards through the tubes of the other half, entering the compartment (5) of the high level tank.

The crude gas leaving the collecting main on top of the ovens enters the plant through a short main (6) and is conducted through the space around the tubes in the heat exchanger (4) in the opposite direction to the liquor, traveling through the tubes. The effect thus produced results in a partial cooling of the gas and a heating of the ammonia liquor. To be able to adjust the effect of the heat exchanger (4), corresponding to the heat requirements of the liquor, it is provided with a by-pass pipe (7) with valve (8) so that by regulating with the latter, a greater or smaller volume of raw gas can be conducted through the heat exchanger (4) or diverted from it, thus enabling the maintenance of a certain desired temperature.

On its further path through the plant, the gas is finally cooled, indicated by the cooler (9), propelled through the plant by the exhauster (70) and passed through acid in the saturator (1)) to recover its vaporous ammonia.

In the heat exchanger (4), the part of the ammonia compounds which can be split under the influence of higher temperatures are decomposed by heat, and free ammonia together with acids like CO_2 and H_2S are liberated. This mixture of vapors collects in the upper part of the compartments (3 and 5) which is not occupied by liquor. The vapors are drawn through the connecting pipe (12) into the gas main (6) after the gas coolers.

The ammonia liquor thus freed from the easily volatilized acids, as well as from the greater part of the ammonia holds, now hold those compounds in solution which must be decomposed by chemical reactions under the influence of alkalies. For this purpose the liquor runs from the compartment (5) by gravity through the pipe line (13) into the decomposing tank.

The latter consists of four vertical chambers (14, 15, 16 and 17) which are separated from each other by means of partition walls, being at the same time interconnected in that the partition between the chambers (14 and 15) and the one between the chambers (16 and 17) does not reach quite down to the bottom while the middle partition between the compartment (15 and 16) is provided with a gate valve (18) immediately under the lid of the tank. Both halves of the decomposer are tapered funnel-like at the bottom and their bottom mouth pieces receive each a sludge valve (19). Above the tapered bottom is arranged in the compartments (14 and 17) a grate (20), fixed on to a central shaft which rests in two external glands and can be turned in the latter so that the grate can be brought into a vertical or horizontal position.

The top of the decomposer carries a lime hopper (21) which by means of a pipe shoot with valve (22) is connected to the top of the chamber (14) and in identical manner with valve (23) to the chamber (17). The lime hopper (21) is shown separately in Fig. 2 and opens on top in a funnel (24) under which a hopper valve (25) is arranged. Inside the lime bin (21) a hopper plate (26) is provided which can be swung from one side to the other by means of a shaft. The respective position of the hopper plate (26) depends upon whether the chamber (14) by means of valve (22) or the chamber (17) by means of the valve (23) are to be fed with lime.

The lime arrives in cars (27) which are emptied into the storage pit (28). From the latter the lime is conveyed according to requirements by means of a skip hoist or an elevator (29) to the top and dumped through the funnel (24) and valve (25) into the bin (21). A suitable amount of lime is drawn from the bin (21) through the valve (22) into the chamber (14) wherein it drops on to the grate (20), having been previously set to horizontal position.

The ammonia liquor pipe line (13) between the decomposer and the high level tank (5) is connected to each of the four chambers (14-17) by means of a valve (30, 31, 32 and 33 respectively) as shown in Fig. 3. If the valve (30) of the chamber (14) be opened, the composer will be filled completely by gravity with the liquor. It travels through the chamber (14) downwards, passes through the lime resting on the grid (20) and forming in dissolving an alkaline zone in the compartment, and ascends again in chamber (17), the grate (20) of which is turned to vertical position. On this long way of travel the ammonia compounds are decomposed by passing through an alkaline zone and any undissolved particles of lime have settled down and the clear liquor which now holds only free ammonia in solution leaves the chamber (17) by the pipe (34) entering the ammonia still (35). The ammonia driven off in the still (35) by steam is conducted through the pipe line (36) connected to the gas main (6) before the saturator (11) or the vapor may be conducted directly into the saturator, depending upon the recovery principle applied to the by-product plant in general.

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*Patent applied for.

The overflow pipe (34) of the decomposer is by means of a valve each connected with the chamber (14, 15, 16 and 17 respectively) to be able to take, if necessary, the liquor from either of the four chambers. This arrangement is better shown in Fig. 3. As in the decomposing of the ammonia salts so high a vapor tension is created that part of the ammonia is liberated as vapor, every compartment of the decomposer is connected from the lid by means of a cock each to the pipe line (37) and the latter is connected to the gas main before the exhauster (6) so that any vapors developed are drawn off and mixed with the gas.

As the liquor leaving the chamber (14) around the partition near the bottom holds still a certain amount of active lime in solution, the vales (31, 32 and 33) are so adjusted that also the chamber (15, 16 and 17) receive a small feed of ammonia liquor from the pipe line (13) in order to utilize the active lime without loss.

After a certain period of working, so much insoluble impurities of the lime will settle down in the bottom of the chamber (14) that the apparatus must be cleaned. To do this without interrupting the working of the still, the way of circulation through the decomposer is reversed by means of corresponding adjustments of the valves. The lime is then, by opening the valve (23) and reversing of the hopper plate (26) fed into the chamber (17), the grate (20) of which has been brought into horizontal position. While the flow through the chambers (14 and 15) is stopped, the liquor runs from the chamber (16) direct to the still.

To clean the chambers (14 and 15), all valves on top of these two chambers are closed and the bottom valve (17) is opened so that the contents run out with the lime sludge into the collecting basin (38) underneath. The sludge settles at the bottom and is washed with water after the ammonia liquor is decanted off through the valves (39) into the accumulating tank of the by-product plant. After the sludge has again settled, the water is decanted off the same way and the lime residue can be shoveled out from the bottom of basin (38).

Immediately after the chambers (14 and 15) have been cleaned—generally they need only be sludged by opening the bottom valves (19) for a short time without emptying the compartments—they can be taken into the liquor circuit again by opening the valve (18) so that the liquor travels then in opposite direction through the decomposer. The grate (20) in the chamber (14) is then set vertically and the liquor leaves by the chamber (14) to enter the still (35). By these means the decomposer can be cleaned completely without interrupting the flow of the liquor or the operating of the still.

Depending upon the amount of heat applied to the liquor in the heat exchanger (4), the original volume of ammonia liquor may be reduced by 50 per cent and as the remainder enters the still as a clear and more or less preheated liquid, the consumption of steam for distilling is reduced considerably, a cleaning of the still is no more necessary, the amount of obnoxious effluent liquor is reduced proportionately and a comparatively very small single column apparatus serves as ammonia still.

To prevent the ammonia liquor in case of obstructions or erroneously closed valves to overflow from the high level tanks (3 and 5) through the pipe line (12) into the gas main (6), the top of the tank (5) is provided with an overflow pipe (40) in the shape of a syphon and connected to the liquor store tank (1).

On plants not recovering the ammonia by the direct process like on independent ammonia plants or on gas works on which the vapors from the heat exchanger and decomposer cannot be returned into the gas main, they are conducted into a saturator to retain the ammonia while as a heating medium for the heat exchanger the foul vapors from the saturators can be utilized and condensed so that only the small uncondensible volume need be absorbed in purifiers.

The advantages offered by this plant are too obvious to call for further comment, attention may only be called to the excellent heat economy by utilizing sources of heat which are otherwise wasted and even employing the heat created by the reaction between the lime and ammonia compounds, while no matter is added to the process for slaking and diluting the lime, saving a corresponding expenditure of steam.

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA HOLD BANQUET.

The forty-third annual banquet of the Engineers Society of Western Pennsylvania was held at the William Penn Hotel the evening of January 23rd and was attended by approximately 600 members. G. S. Davidson, President of the Gulf Refining Company acted in the capacity of toast master, while Henry D. James, President of the Engineers Society presided. The speakers of the evening included Governor H. J. Allen of Kansas, E. A. S. Clark, President of the Consolidated Steel Corporation, New York, and E. J. Cattell, statistician of Philadelphia.

In discussing the "Responsibility of the State for Industrial Relations," Governor Allen described the Kansas industrial relations court and stated that in the two years of its life, 38 out of 40 cases brought before it, have been settled amicably and acceptable to both capital and labor. He said he is not opposed to labor unions and pointed out that 75 per cent of the court's decisions were in favor of labor notwithstanding the fact that all opposition against it had originated with labor leaders, 150,000 of whom draw annually approximately $60,000,000 from the pockets of American workmen. Stating that progress of humanity has been due to betterments of labor and labor conditions, Governor Allen said:

"No peace can exist between employes and employers until an honest day's work brings an honest day's pay and an honest day's pay brings an honest day's work. This cannot be brought about so long as labor secretaries of war, its so-called leaders, are the controlling factors. The state has the right to protect the public against strikes and the Kansas law has been written upon the old principle that the safety of the public should be the supreme law. The Kansas industrial court does not take away the man's rights to quit work; but it holds that the right to work is as sacred as the right to loaf and that no combination of capital or of labor should be allowed to bring economic pressure to bear in an essential industry relating to food, fuel, clothing and transportation."

E. A. S. Clarke, president of the Consolidated Steel Corp., New York, read a paper upon "Foreign Trade." He stated that the whole world is one great market awaiting development and while at the present time there does not seem to be enough business from domestic sources to keep mills and men active, methods, financial and otherwise will be found to revive export trade so as to make it pay real dividends.

E. J. Cattell, statistician of Philadelphia, entertained with humorous anecdotes.

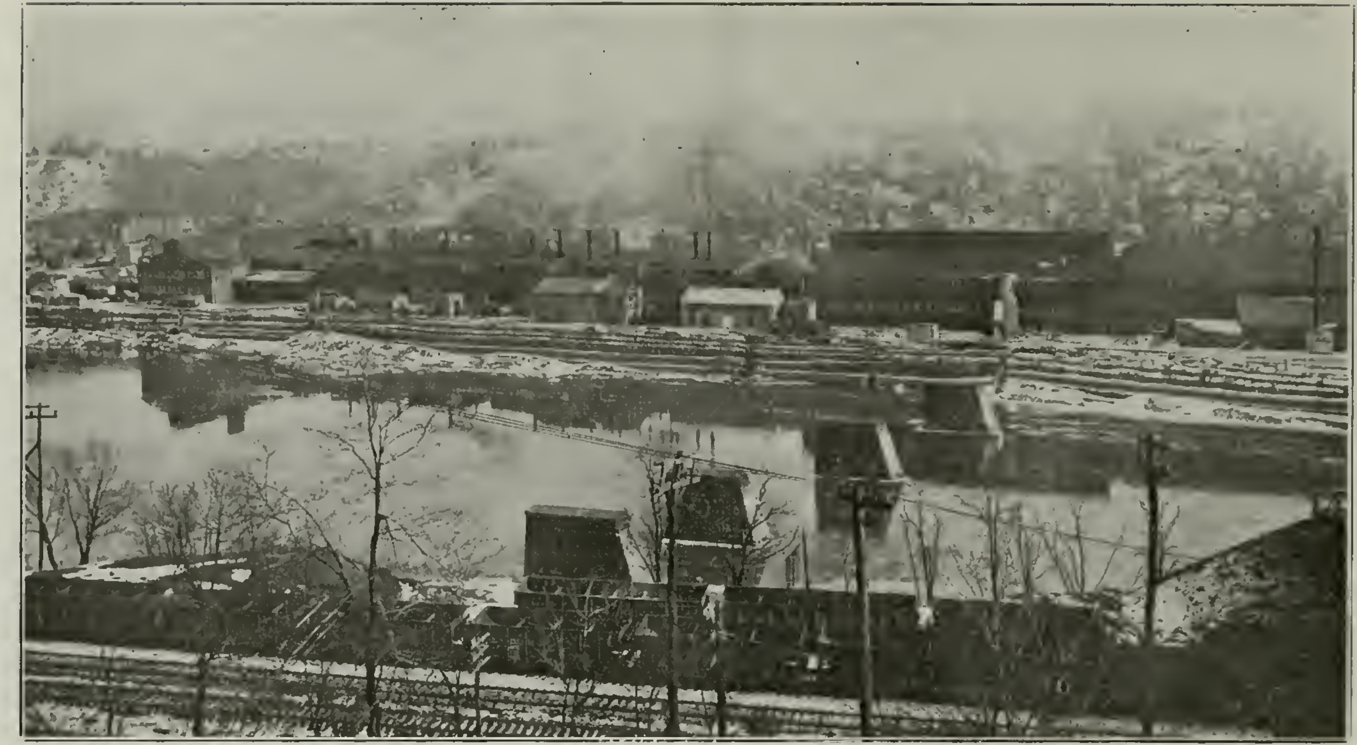


Fig. 1—Lower portion of the plant.

Apollo Steel Company Enlarge Plant by the Addition of a New Sheet Mill Unit

Two Jobbing Mills and Four Additional Sheet Mills Were Added to the Original Plant—Modern Improvements in Sheet Mill Construction Feature the New Additions.

THE Apollo Steel Company, located at Apollo, Pa., on the right bank of the Kiskiminetas river, have just completed an extension to their plant which will enable them to manufacture sheets in all gauges from 10 to 30, and widths up to 60 inches, and will contain also black plate mills for the manufacture of light gauges for export.

General Layout of Plant.

The original works of this company, which were built in 1912, consisted of six 28-in. sheet mills, with range in width from 24 in. to 40 in., with cold rolls, annealing furnaces, and a pickling and galvanizing plant. In 1918 two hot mills were added, making the plant an 8-mill unit. However, the trend of business required larger and heavier sheets than could be rolled on the 28-in. mills and plans were made to build two 32-in. jobbing mills and four additional sheet mills on adjoining land.

The general layout of the new plant as furnished by the United Engineering & Foundry Company was accepted. It was, however, modified considerably during construction. The actual construction began in May, 1920, when all building foundations were put in by the Mill Company. The delivery and erection of the buildings was greatly delayed by strikes and they were not under roof until January 1921. The buildings were manufactured by the Blaw-Knox Company.

The general view and layout of the plant shows how the prevailing thought in the construction of the new extension was to provide plenty of working space, light and ventilation, so that conditions for the workmen would be as near ideal as possible.

Buildings.

The furnace building has a width of 75 ft. The mill building proper is covered by a crane with a 68-ft. span. The shears and continuous annealing furnaces are housed in a 38-ft. wide building. These three buildings each have 15 bays at 24 ft. or are 360 ft. in length. They are provided with ventilating top hung steel sash in the roof, the full length of the buildings, and every other bay is arranged with lifting doors on the west, south and east. This gives the works the full benefit of fresh air currents coming from any special direction. The three box annealing furnaces are built in a lean-to 152 ft. long and 32 ft. wide which is alongside the annealing and pickling building. This building runs north to south and has a total length of 410 ft. by 72 ft. wide. The ventilation of the building has also been taken care of

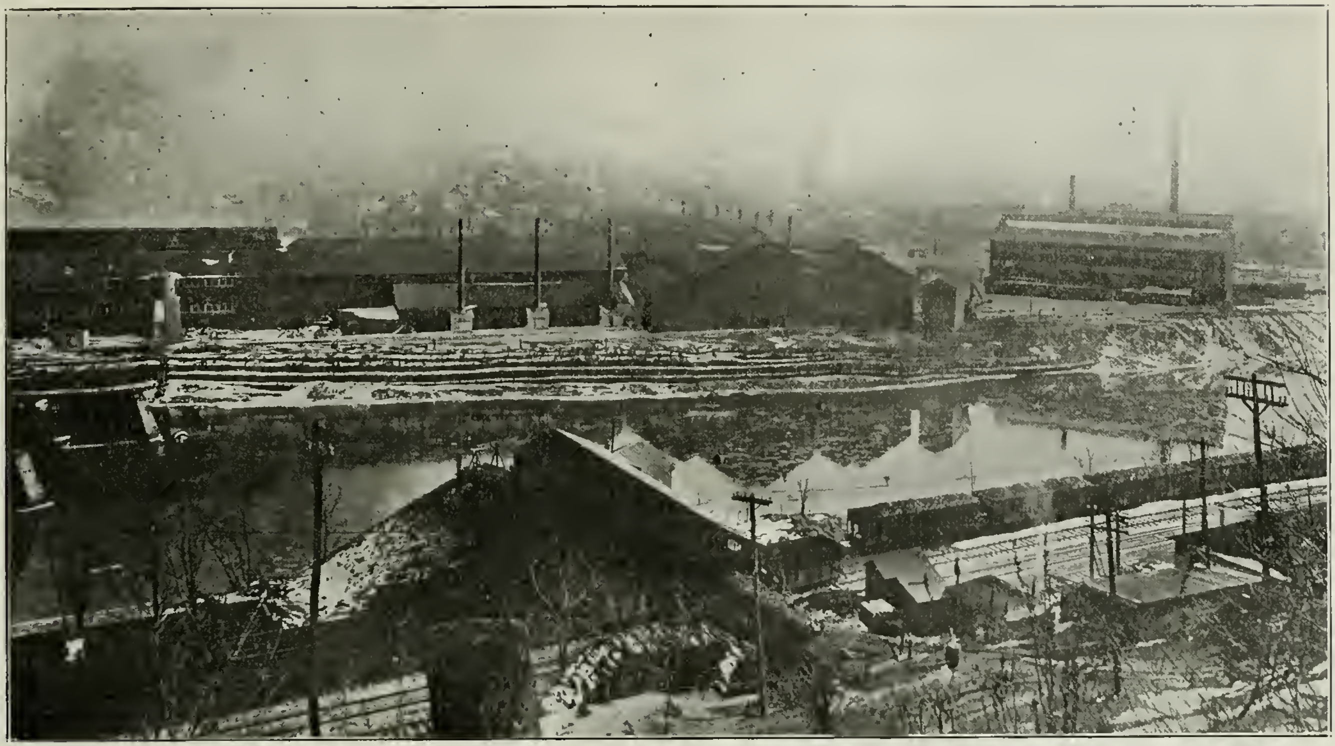


Fig. 2—Upper portion of the plant.

by continuous sash in the skylight and large doors that open on the river side.

The warehouse, which will take care of the products of both the old mill and the extension is a steel building with brick curtain walls and has a generous area of windows. In this connection it may also be stated that all the buildings have been provided with an artificial light system, by which large incandescent flood lights make the illumination by night as even and bright as by the natural daylight. The floors in all the buildings are of brick except in the warehouse, where steel plate runways are laid on concrete slabs, making trucking easy. The sanitary conveniences include three comfort stations built in accordance with latest standards. The drinking water cooling system is installed with distribution pipes encircling the whole plant.

Furnaces.

The furnace equipment, which was furnished by the Hagen Company, consists of four combination sheet and pair furnaces, two Costello continuous blue annealing furnaces and three double box annealing furnaces. All furnaces except the Costello furnaces are designed for coal firing with stokers, the drive for which on the sheet and pair furnaces and also the slab furnaces is underground in specially designed pits so that easy access to all machinery is available. The Costello furnaces are gas fired and are equipped with the Surface Combustion Company's gas mixer, regulator, and burners, it being the company's aim eventually to install gas in all furnaces.

Mills.

The mills and auxiliary equipment were furnished by the United Engineering & Foundry Company and is the last word in sheet and jobbing mills design. The housings are of exceptionally heavy construction and are made of cast steel. On the east side of the drive are the two 32-in. jobbing mills. These mills are two high mills 32 in. in diameter by 66 in. length of rolls. The roughing mills are balanced and have a motor driven screw down, and are also provided with catchers lifting table. The finishing mills have a lifting table on the catchers side and the gap between these tables and the Costello furnaces is bridged by a set of casters.

A single stand of cold rolls acts as a drag on the end of the drain. To facilitate the delivery of hot slabs from the furnaces to the mills an overhead trolley track has been installed as shown on the photograph of the mill.

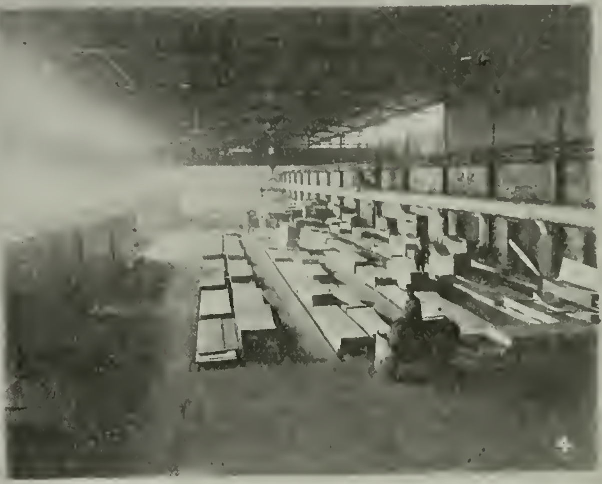
The west end of the train, consisting of two 32 in. by 54 in. finishing mills with common roughing stand and a cold roll stand, is connected to the drive through a turned steel shaft. These mills are equipped with not only doublers, but also with doublers shears for making light gauge black sheets. Two 156-in. squaring shears will take care of these four mills, and a 40-ton transfer car electrically operated will carry out all of the box annealing furnace building.

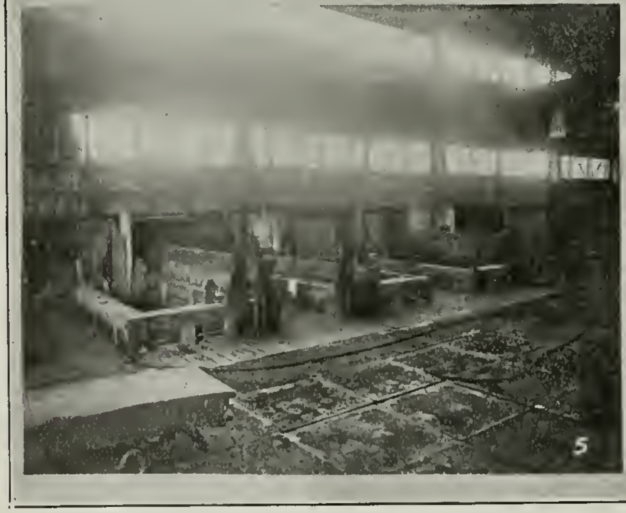
Drive.

The mills are driven by an 1,800-hp. General Electric Company motor running at 240 rpm. through an 8 to 1 reduction—herringbone gears. This drive is almost a copy of the drive for the old mill, installed in 1912 At this time this drive was the first of its kind installed, while now it is almost universally used on all sheet mills. The United Engineering & Foundry Company designed and built these drives. A complete Bowser oiling system takes care of all the bearings of the drive.

Sheet Mill Floors.

Realizing that cool floors are not only a great help to increased production, but also a modern convenience for the mill worker, and with water cooled floors out of the question on account of the water supply being acute, inasmuch as the river is strongly acid and only salt water can be secured from the wells sunk on the property, experiments were conducted with grate flooring in front of the finishing mills, and found efficient. Incidentally,





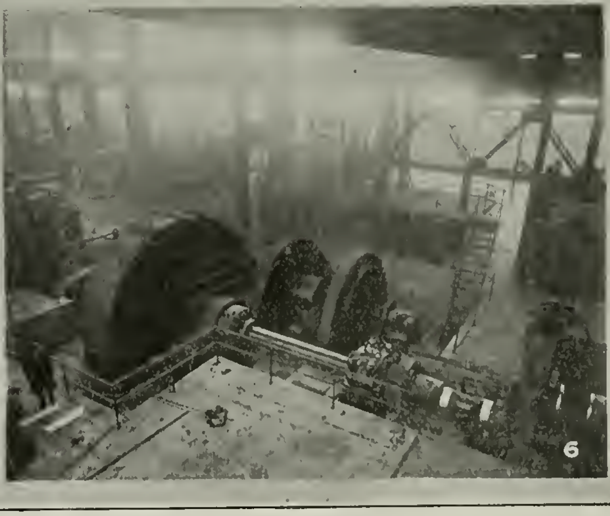


Fig. 1—View of Geo. J. Hagan Co. annealing furnaces.

Fig. 3—Interior view of power station. All electrical equipment in the plant was furnished by General Electric Co.

Fig. 5—View of the pickling department.

Fig. 2—View of hot mill department.

Fig. 4—Interior view of the new warehouse.

Fig. 6—General Electric Co. 1,800 hp motor which drives the mills.

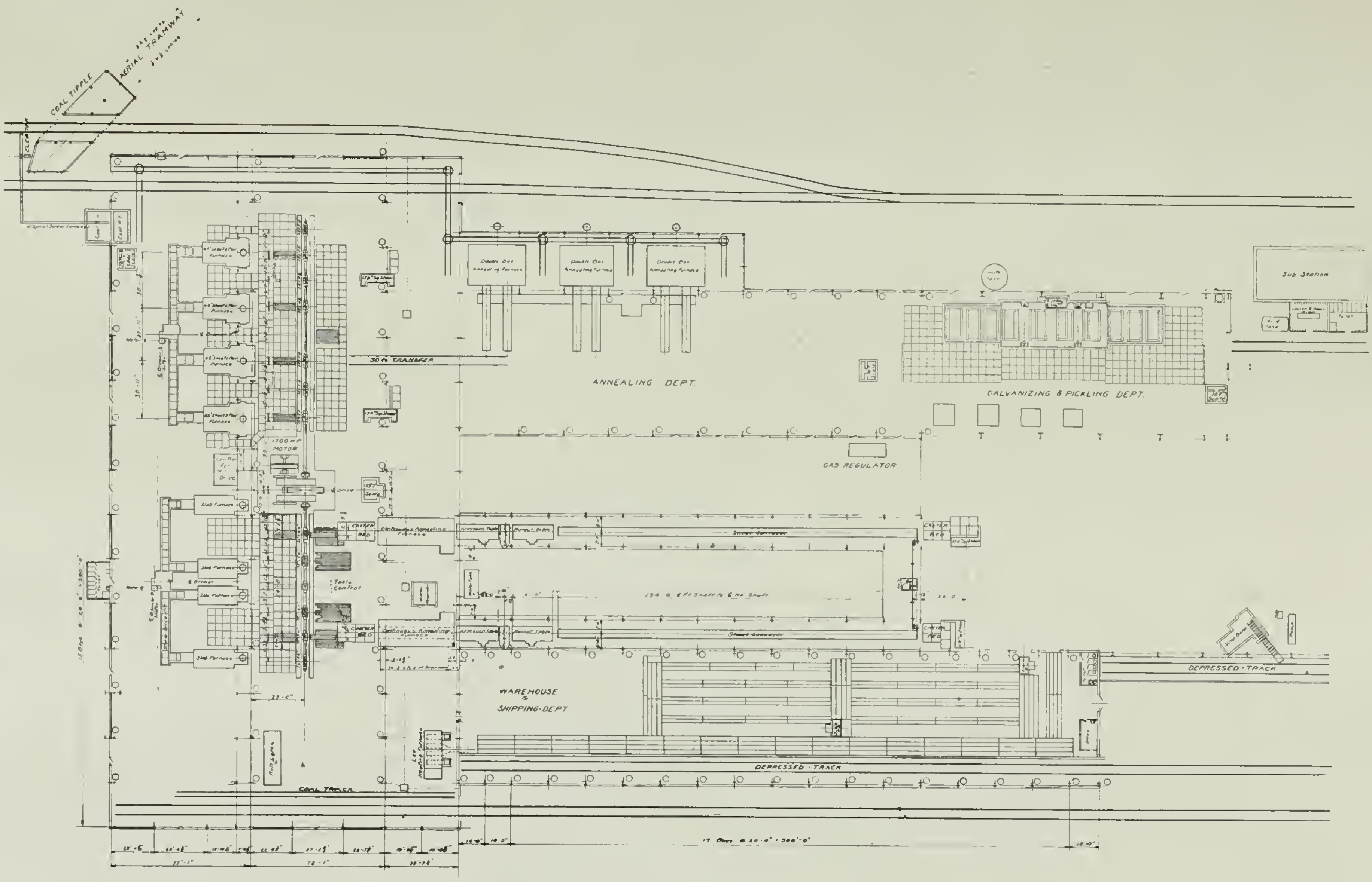

COAL TIPPLE
AERIAL TRAMWAY
Sub Station
Double Box Annealing Furnace
Double Box Annealing Furnace
Double Box Annealing Furnace
ANNEALING DEPT.
GALVANIZING & PICKLING DEPT.
GAS REGULATOR
30 ft TRANSFER
1700 H.P. MOTOR
Table Control
Continuous Annealing Furnace
Continuous Annealing Furnace
Sheet Conveyor
Sheet Conveyor
WAREHOUSE & SHIPPING DEPT
DEPRESSED · TRACK
DEPRESSED · TRACK
COAL TRACK
22'-6"
19 Bays @ 20'-0" = 300'-0"
10'-0"
14'-0"
72'-1"

Fig. 7—General plan of the new mills.

a large saving in operating cost was made as a result of obviating the use of water. The grating is laid over an open air space about 18 in. deep and was demonstrated at the old mill to be satisfactory, as it remains cool in the hottest summer weather and is non-slipping.

Finishing.

The product from the two jobbing mills is moved mechanically through the Costello blue annealing furnaces to a set of tables, and then to a Newhold roller leveler, and then on another set of tables it is carried to a conveyor designed by the steel company and built by the Chain Belt Company. This conveyor, which is 165 ft. in length, takes the sheets to the shears, located in the upper end of the old mill building. Here the sheets are squared or stored for shipment.

The sheet mill product goes through the annealing furnaces to the black warehouse, or to the pickling tanks, of which four are built in two units driven by a common motor. These tanks are of the plunger type, and the complete equipment was designed by the company. The tanks were built by the mill shops, while the machinery was manufactured by the United Foundry & Machine Company, Canton, Ohio The pit in which the tanks are placed is concrete, lined with bricks, with sulphur run in the joints. Provisions have been made for making possible the installation of the copperas plant later on. The original installation of four galvanizing pots has not been enlarged as yet, but plans have been made for two additional pots and a modern dryer.

The warehouse has, as the photograph shows, a depressed track, so that all loading and shipping is done indoors. The heating of this building is by hot air, the air being moved from the warehouse through the heating tubes of a Lee furnace and distributed in the warehouse by a Sturtevant fan. The B. F. Sturtevant Company furnished the induced draft fan, the distribution fan and the distribution pipes.

The power situation at this plant is unique, as all the current is purchased and no boiler equipment is used except a small heater for the pickle. General Electric Company furnished all the electric equipment used in the new additions.

The electric power is furnished by the West Penn Power Company and is stepped down from 22,000 to 2,200 volts at the transformers under transmission tower on the river bank. Both the 1,400-hp. motor for old installation and the 1,800-hp. for new mills use the 2,200-volt current set in substation used for furnishing d.c. for screw down and mill table motors.

The cranes in this extension are all Cleveland cranes, one 15-ton in the furnace building, a 30-ton with 10-ton auxiliary in annealing, and one 15-ton over the pickling and galvanizing department. The warehouse crane is a 15-ton crane.

For turning rolls, a 42-in. heavy duty enclosed Headstock type roll turning lathe, designed and built by United Engineering & Foundry Company, has been provided. A 36-in. Gridgeford engine lathe has been installed to take care of the heavier work in connection with the larger mill units.

Raw material can be delivered to the plant at either end of the mill building. Ample floor space in the furnace building has been provided for bars and slabs.

The coal supply is arranged for from a mine on the opposite bank of the Kiskiminetas river via aerial tramway to a 75-ton bin, under which a Jeffrey crusher is located, crushing the coal, then elevating it. This elevator has delivery on the one side to a screw conveyor, on the other side the chute delivers the coal to a railroad car. The screw conveyor takes the coal direct to a bin with a pit in the front, so as to load coal boxes for delivery to the furnaces in the new mill. The coal dumped in the railroad car is transferred to the coal bin (under track) at the old mill, from which it is distributed to furnaces. It may be added that the only manual work on this side consists of noting the weight of each full bucket as it comes on the scales. The discharge of the buckets is done automatically, and the drive rope is running continuously.

The estimated output of this extension, combined with the original plant, gives the Apollo Steel Company a capacity of approximately 120,000 N. T. in the one pass cold rolled and galvanized sheets up to 48 in. wide, and blue annealed sheets up to 60 in. wide.

LIGNITE AS A HIGH GRADE FUEL.

Lignite, or "brown coal," which constitutes approximately one-third of the Nation's coal resources, can be converted by carbonization into a high grade fuel adapted to a wide range of purposes and limited only by its relative cost, according to a statement issued by Director H. Foster Bain of the United States Bureau of Mines. It cannot, however, be classed as a cheap fuel in the sense of competing with a high class, easily mined bituminous coal.

A lignite carbonizing plant has been erected by the University of North Dakota at Hebron, North Dakota, in a field whose lignites are similar to those found in the Nenana field in Alaska. Dr. E. J. Babcock, dean of the engineering department of the university, has been for years directing experiments in carbonizing and briquetting lignite and has made notable progress.

During the past summer, the United States Bureau of Mines has cooperated with the university in the operation of the plant, and more than a thousand tons of raw lignite have been treated and more than 400 tons of lignite char briquettes were produced, this being probably the largest amount of lignite char briquettes that has ever been made at one time.

By removing the moisture and a considerable portion of the volatile matter from the raw lignite, a char can be obtained which possesses a heating value and chemical analysis quite similar to anthracite coal. In this process, a ton of raw lignite will yield forty per cent of high grade lignite char. The physical form of this char is such that approximately one-third of it will go through a one-eighth inch screen, the remainder up to pieces the size of shelled corn. By the addition of eight to ten per cent of suitable binding material, excellent briquettes can be made, whose heating value and availability for general use is little less than that of Pennsylvania anthracite.

The fixed carbon in these briquettes may run from 72 to 81 per cent, as compared with that of 35 per cent in raw lignite. This makes it practicable to transport the fuel to much greater distances than would be practicable with raw lignite. The briquettes are pillow-shaped, weighing about two and a half ounces each. When produced with suitable skill, the briquettes will stand handling, transportation and weather conditions in storage. The product is a stable one, thus removing the greatest limitation to the usefulness of the original lignite.

Graphical Treatment of Stack Gas Analysis and of Producer Gas Analysis

Graphical Representation of Producer Gas Analysis—Review of Graphic Charts as Introduced by W. Ostwald.

By W. TRINKS

PART II

On pages 44 to 57 of his book on "Graphics of Combustion Engineering," Mr. Ostwald takes up the gasification of carbon. Upon Ostwald's work as a foundation, Claus & Neussel have built a rather complete theory of the gasification process (Z. d. V. D. I., No. 29, of 1921). The following derivations follow the same reasoning as these two publications, using, however, a shorter and more direct method for the construction of the principal diagram.

Gasification in the producer takes place in three stages, which are drying, distillation of volatile matter, and gasification of carbon. In consequence, producer gas contains water vapor, products of distillation, and products of gasification. In the analysis of producer gas, as it is commonly made, water vapor as well as all condensable tar vapors do not appear, but ethylene, methane, CO, CO_2, H_2, and N_2 are found. Ethylene and methane are not products of gasification of carbon, but of distillation, which means that gasification of carbon produces only CO, CO_2, and H_2, with N_2 as a diluting gas. As far as gasification is concerned, the quality of the producer gas depends solely upon the percentages of CO, CO_2, and H_2, or, in other words, in the gasification zone of every producer, coke is gasified, no matter what the nature of the original coal might have been when charged. For this reason, the theory concerns itself at first only with the gasification of pure carbon.

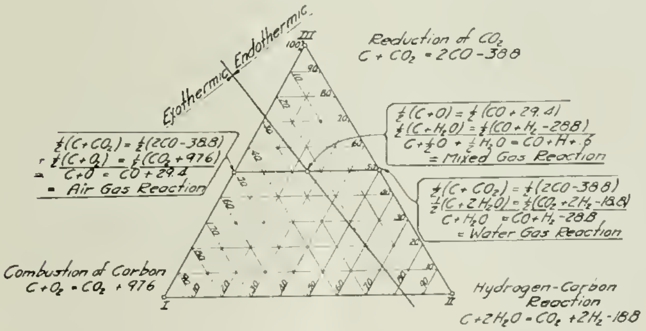

Exothermic
Endothermic
III
100
Reduction of CO_2
$C + CO_2 = 2CO - 38.8$
$\frac{1}{2}(C+CO_2) = \frac{1}{2}(2CO - 38.8)$
$\frac{1}{2}(C+O_2) = \frac{1}{2}(CO_2 + 97.6)$
$C + O = CO + 29.4$
= Air Gas Reaction
$\frac{1}{2}(C+O) = \frac{1}{2}(CO + 29.4)$
$\frac{1}{2}(C+H_2O) = \frac{1}{2}(CO + H_2 - 28.8)$
$C + \frac{1}{2}O + \frac{1}{2}H_2O = CO + H + .6$
= Mixed Gas Reaction
$\frac{1}{2}(C+CO_2) = \frac{1}{2}(2CO - 38.8)$
$\frac{1}{2}(C+2H_2O) = \frac{1}{2}(CO_2 + 2H_2 - 18.8)$
$C + H_2O = CO + H_2 - 28.8$
= Water Gas Reaction
Combustion of Carbon
$C + O_2 = CO_2 + 97.6$
I
II
Hydrogen-Carbon Reaction
$C + 2H_2O = CO_2 + 2H_2 - 18.8$

Fig. 1.

The process of gasification of pure carbon by air and steam cannot be expressed in a single equation, but yet there corresponds to each gas analysis only one combination of the various equations, and it is wholly immaterial from a thermochemical standpoint through what intermediate steps the final composition of the gas has been reached.

From the eight reaction equations, Ostwald selected three which lend themselves most readily to being used in a graphical representation. For the latter he uses Gibbs' equilateral triangle, see Fig. 1, to the three corners of which correspond the following equations:

a) $C + O_2 = CO_2 + 97.6$
b) $C + 2H_2O = CO_2 + 2H_2 - 18.8$
c) $C + CO_2 = 2CO - 38.8$

In these equations the symbols represent metric mols (gram-molecules) while the figures are gram-calories. The equations can be converted into pound molecules by multiplication of the figures by $\frac{1,000}{2.2} \times 2.2 \times 1.8$, because one pound = 1,000/2.2 grams, and a kilogram calorie = 2.2 × 1.8 Btu. It may also be remarked that a metric mol of carbon = 12 grams.

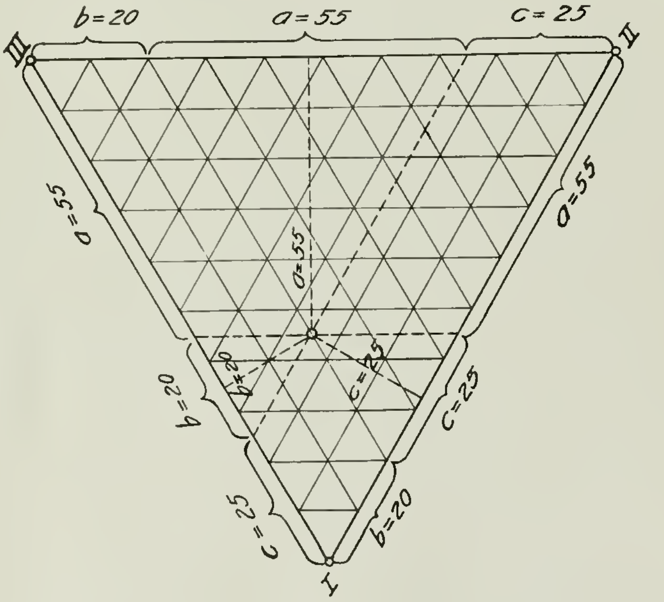


Fig. 2.

In the illustration, Fig. 1, the reactions for, and the significance of some of the more important points of the triangle are given in detail.

Further information on the properties of the gasification triangle can be gained by addition of the equations a), b), and c). The result is $(a + b + c)\ C + aO_2 + 2bH_2O + cCO_2 = (a + b)\ CO_2 + 2bH_2 + 2cCO + 97.6a - 18.8b - 38.8c$. This means that, of (a + b + c) parts of carbon, **a** parts react as in equation a), **b** parts react as in equation b), and **c** parts as in equation c). Rearrangement of the terms furnishes $(a + b + c)\ C + aO_2 + 2bH_2O = (a + b - c)\ CO_2 + 2bH_2 + 2cCO + 97.6a - 18.8b - 38.8c$.

If the length of each side in the triangle equals 1, then $a + b + c = 1$; but if the length of that side equals 100, then $a + b + c = 100$. This latter figure was used in Fig. 2, in which $a = 55$, $b = 20$, and $c = 25$. If dilution nitrogen is added, then

$$100\ C + 55\ O_2 + 55 \times \frac{15N_2}{4} + 40\ H_2O = 50\ CO + 40\ H_2 + 50\ CO + 55 \times \frac{15}{4}\ N_2 + 4034.$$

The right hand member of the equation corresponds to a gas analysis of 14.4 per cent CO_2, 14.4 per cent CO, 11.5 per cent H_2 and 59.7 per cent N_2. This is a very poor gas, but it will do for an example.

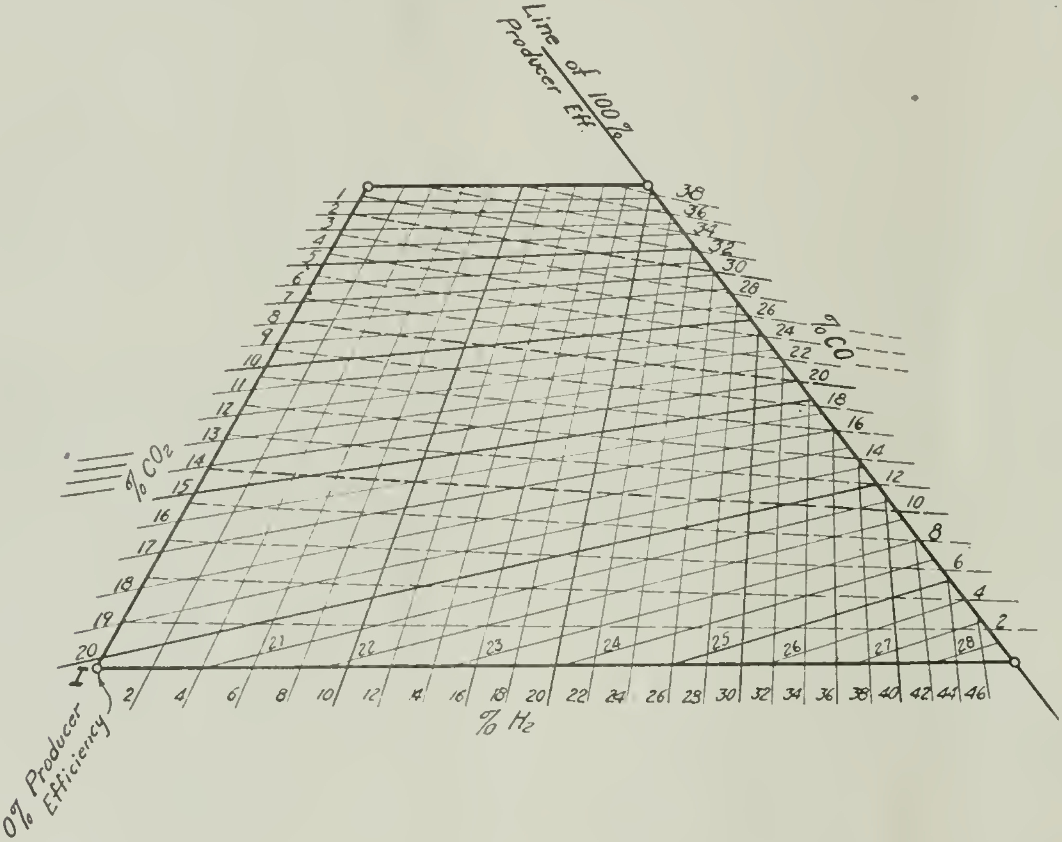


Fig. 3.

The figure in the right hand member indicates the heat which is liberated by the reaction. If the figure is negative, heat from an outside source is required for the reaction. The line which crosses the triangle in Fig. 1, from the upper left hand corner to the lower right hand corner, separates the endothermic from the exothemic field. That line follows those reactions which neither liberate nor use up heat. It has been called the "neutro-caloric" line by Ostwald. For all practical producer gas work, reactions which require heat from an outside source need not be considered, and in consequence, the right hand strip can be eliminated from the triangle, see Fig. 1. Of the remaining triangle, the top can be eliminated, because, in the top section, addition of CO_2 from an outside source is required, and such addition is not used in ordinary producer practice.

So far, the chart shows only the possible proportions of the carbon gasified according to each of equations a), b), and c). For any reaction corresponding to a point in the triangle, it is possible to calculate the CO_2, CO, and H_2 contents from these equations, taking care to include, of course, the dilution nitrogen which enters with the oxygen. But the attempt to reverse the process, and to locate a point in the triangle corresponding to a gas composition, either assumed or determined by analysis, meets with difficulties; for, while in the first procedure, any values of a, b, and c may be taken, as long as $a + b + c = 1$, in the reverse process the sum of $(CO_2 + CO + H_2)$ is not equal to unity, or to any constant sum.

It is evident, then, that a very desirable addition would be a network of lines of constant CO, H_2, and CO_2 spread over the triangle. In the article referred to above, Clause and Neussel construct such a network by means of the detour of a proportion-triangle with lines of constant ratios $\frac{CO_2}{H_2}$, $\frac{CO_2}{CO}$, $\frac{H_2}{CO}$. The chart which they derive thereby is shown in Fig. 3. It includes a correction for methane content, as will be explained later. The chart applies to coals having a very large amount of volatile matter, but does not consider the addition of hydrogen from breaking up of the heavy distillates due to heat. The network of lines of constant CO_2, CO, and H_2 can, however, be located directly, as in the following original derivation:*

Pure carbon is first considered, and is regarded as being in the gaseous form when the reaction occurs. (See article in January issue.) Repeating equations a), b), and c) in slightly different form, we find

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*This derivation was made by J. D. Keller, mechanical engineer with Prof. Trinks.

a) $C_2 + 2\ O_2 = 2\ CO_2$
b) $C_2 + 4\ H_2O = 2\ CO_2 + 4\ H_2$
c) $C_2 + 2\ CO_2 = 4\ CO$

Of one (equivalent) cubic foot of C_2,

a cu. ft. reacting as in equation a), require **2 a** cu. ft. of O_2 and produce **2 a** cu. ft. CO_2.

b cu. ft. reacting as in equation b), require **4 b** cu. ft. H_2O (vapor) and produce **2 b** cu. ft. CO_2 and **4 b** cu. ft. H_2.

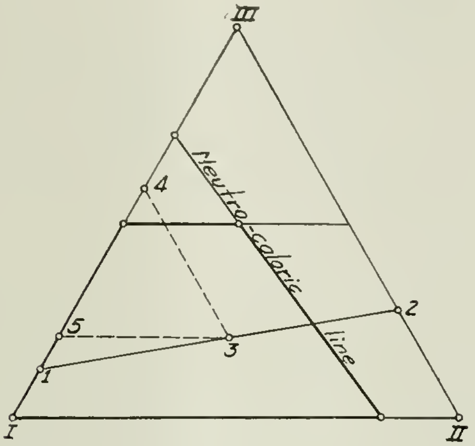


Fig. 4.

c cu. ft. reacting as in equation c), require **2 c** cu. ft. CO_2 and produce **4 c** cu. ft. CO.

a, b and **c** in this case represent fractions of one cubic foot.

Total volume of CO_2 produced = $(2a + 2b - 2c)$.
Total volume of CO produced = 4 c.
Total volume of H_2 produced = 4 b.

Since with 1 cu. ft. of oxygen from the air, there are associated $\frac{79}{21}$ or (very closely) $\frac{15}{4}$ cu. ft. of nitrogen, the total volume of N_2 included $= \frac{15}{4} \times 2a = \frac{15}{2}a$.

As no excess air can exist in producer operation, no free oxygen is present.

A summing up furnishes the total volume of gases from 1 (equivalent) cu. ft. of carbon $= 2a + 2b - 2c + 4c + 4b + \frac{15a}{2}) = \frac{19a}{2}. + 6b + 2c$. And since $(a + b + c) = 1$, this sum may be written in the form $\frac{19a}{2} + 6b + 2\ (1 - a - b) = \frac{15a}{2} + 4b + 2$.

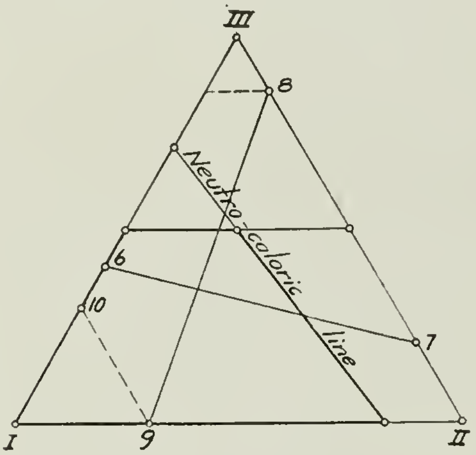


Fig. 5.

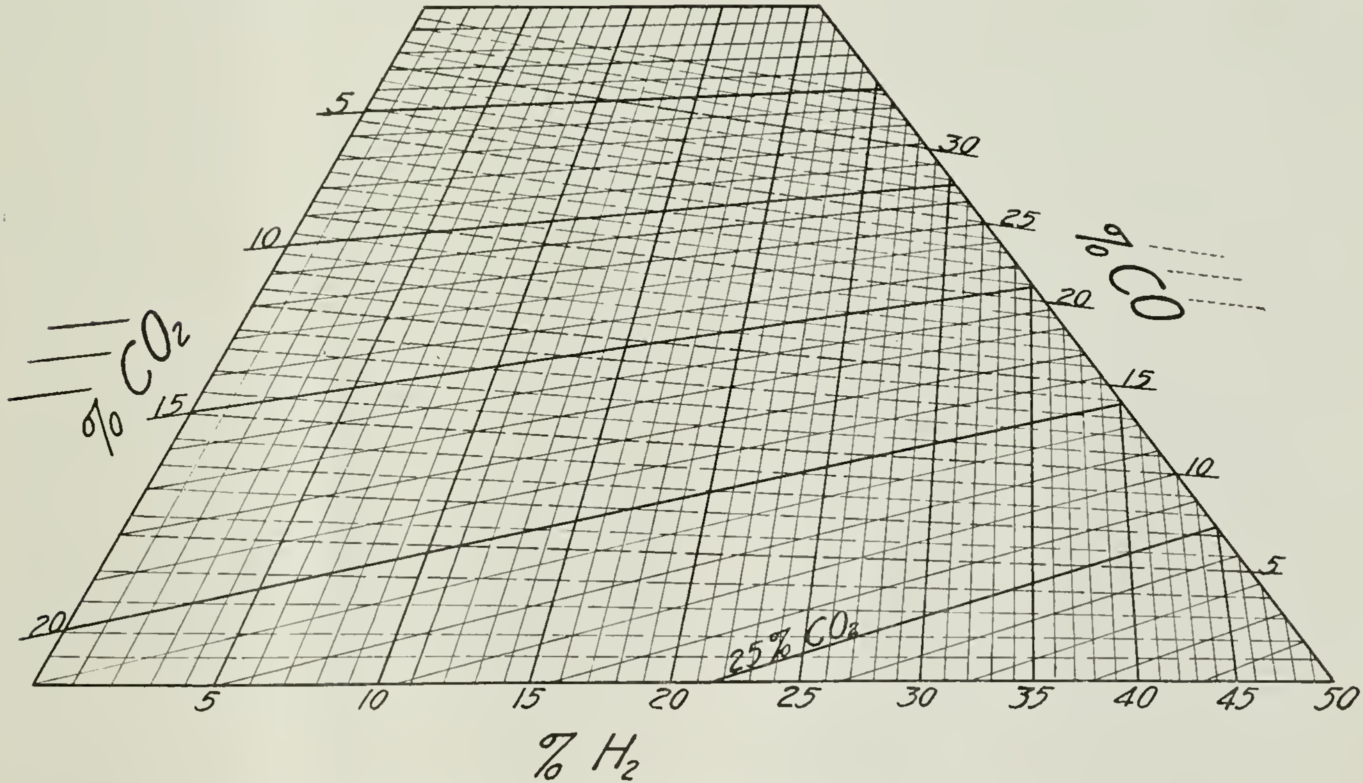


Chart for Gasification of Pure Carbon

Fig. 6.

The proportion of CO_2 by volume, designated by the symbol **k**, may be expressed as

$$k = \frac{\%\ CO_2}{100} = \frac{2a + 2b - 2c}{\frac{15}{2}a + 4b + 2} = \frac{2a + 2b - 1}{\frac{15}{4}a + 2b + 1}$$

From this equation,

$$\frac{15}{4}ak + 2bk + k = 2a + 2b - 1$$

Solving for b, we find

$$b = a\left[\frac{15/8\,k - 1}{1 - k}\right] + \left[\frac{k + 1}{2 - 2k}\right] \qquad \text{I.}$$

The proportion by volume of CO, designated by **p**, is

$$p = \frac{\%\ CO}{100} = \frac{4c}{\frac{15}{2}a + 4b + 2} = \frac{2 - 2a - 2b}{\frac{15}{4}a + 2b + 1}$$

$$b = \left[\frac{2 - p}{2 + 2p}\right] - a\left[\frac{1 + 15/8\,p}{1 + p}\right] \qquad \text{II.}$$

The proportion by volume of H_2, designated by **h**, is

$$h = \frac{\%\ H_2}{100} = \frac{2b}{\frac{15}{4}a + 2b + 1}$$

$$b = \left[\frac{h}{2 - 2h}\right] + a\left[\frac{15/4\,h}{2 - 2h}\right] \qquad \text{III.}$$

To locate points on that line in the triangle which corresponds to a given fixed percentage of CO_2, values of **b** corresponding to various values of **a** are calculated from equation **I** above for the constant value of **k**. For each pair of values, **a** is laid off in Fig. 4 as length III — 4, and **b** is laid off as length 4 — 5. Line 4 — 3 is drawn parallel to side of triangle III — II, and line 5 — 3 is drawn parallel to side I — II. Their intersection locates point 3.

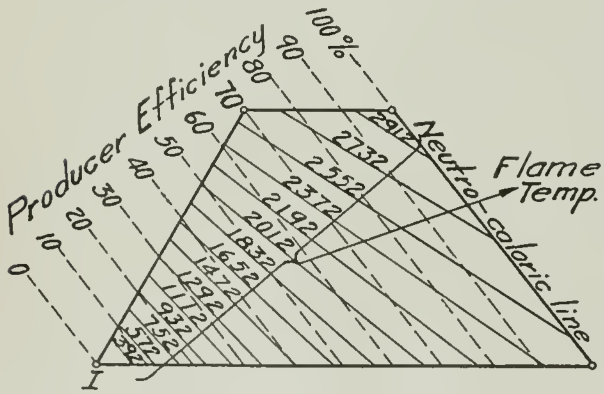


Fig. 7.

Now it can be proved quite simply, by the methods of analytical geometry, that the locus (line 1 — 2) of all points corresponding to a fixed CO_2 content is a straight line,—hence for constructing the network of lines of constant CO_2 content, it is only necessary to locate corresponding points 1 and 2 on lines I — III and II — III, and to draw straight lines connecting 1 with 2. To locate point 1, equate **b** to zero, in equation **I**.

$$a = \frac{\left[\frac{k + 1}{2 - 2k}\right]}{\frac{15/8\,k - 1}{1 - k}} = \frac{k + 1}{2 - \frac{15}{4}k}$$

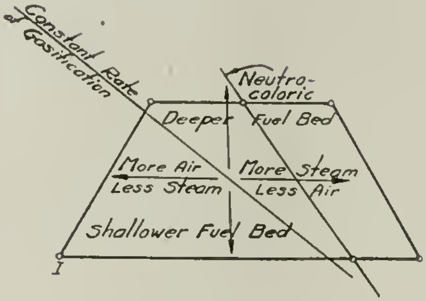


Fig. 8.

For each value of **k**, the fraction **a** is calculated, and is represented by length III — 1, such that

$$a = \frac{\text{length (III — 1)}}{\text{length (III — I)}}$$

To locate point 2, equate **a** to zero in equation **I**.

$$b = \frac{k + 1}{2 - 2k}$$

The calculated value of **b** may be laid off on line 1 — III and a parallel to line I — II may be drawn to intersection with II — III; or more simply, **b** may be laid off directly on line II — III to such scale that

$$b = \frac{\text{length (III — 2)}}{\text{length (III — II)}}$$

Example: Locate the line representing constant CO_2 content of 15 per cent.

$$\text{When } b = 0,\ a = \frac{k + 1}{2 - \frac{15}{4}k} = \frac{.15 + 1}{2 - 15/4 \times .15} = .80$$

If the sides of the triangle I—II, II—III, and III—I, (Fig. 4) are made 10″ long, then **a** = .80 =

$$\frac{\text{length (III — 1)}}{10''}$$

Length (III—1) = 8″ and this locates point 1.

$$\text{When } a = 0,\ b = \frac{k + 1}{2 - 2k} = \frac{.15 + 1}{2 - .30} = .676$$

Then length (III—2) is .676 × 10″ = 6.76″. This locates point 2.

Lines of constant CO (as 6—7, Fig. 5), and those of constant H_2 (as 8—9), can also be proved to be straight lines. To construct these lines, it is only necessary to find their end points, as 6 and 7 for CO, 8 and 9 for H_2; and to connect the corresponding points by straight lines.

For constant CO content, point 6 is found by equating **b** to zero, in equation **II**.

$$\text{Then } a = \left[\frac{2 - p}{2 + 2p}\right] \div \left[\frac{1 + 15/8\,p}{1 + p}\right] = \frac{2 - p}{2 + \frac{15}{4}p}$$

length (III—6) = **a** × length (III—I)
Point 7 is found by equating **a** to zero.

$$b = [\frac{2 - p}{2 + 2p}]$$

length (III—8) = b × length (III—II)

For constant H_2 content, point **8** is found by equating **a** to zero, in equation **III**.

$$b = \frac{h}{2 - 2h}$$

In Fig. 5, length [illegible]I—8) = **b** × length (III—II). Point 9 is found by equating the sum of (a + b) to unity,—that is, $c = 0$.

$$(1—a) = \frac{h}{2 - 2h} + a\ [\frac{15/4\ h}{2 - 2h}]$$

$$a = [\frac{2 - 3h}{2 + \frac{7}{4}h}]$$

Lay off length (III—10) equal to **a** × length (III—I), and draw line 10—9 parallel to III—II to intersection point 9; or else (more simply) lay off length (II—9) = **a** × length (II—I). As the triangle is equilateral, I—II = II—III = III—I.

The chart of Fig. 6 has been constructed in this manner. It may be noted that the lines of CO_2 and H_2 are nearly at right angles. This means that their intersection points are sharply defined and that from an analysis showing only CO_2 and H_2, the corresponding CO content can be found quite accurately. This is an advantage, because no good reagent is known for absorbing CO in the gas analysis, whereas excellent absorbents for CO_2 and H_2 are known. The chart can be applied very advantageously to indications of these constituents from such instruments as the Mono recorder.

The chart of Fig. 6 applies only to gas produced from coke or anthracite. Producer gas formed from bituminous coal or from lignite contains also methane, ethylene, and the additional hydrogen which is formed by the breaking up of the hydrocarbons. In the chart constructed by Claus and Neussel, Fig. 3, a correction was introduced for the methane, but not for the extra hydrogen. Gas from bituminous coal always contains more hydrogen than the chart (Fig. 3) shows, but the amount of excess hydrogen is indeterminate for this reason: The amount of extra hydrogen depends upon the temperature at the top of the producer; the higher this temperature, the greater the extent to which the hydrocarbons are decomposed, and the greater the amount of extra hydrogen produced.

But the top of the producer is hottest, when gasification proceeds with reactions which are represented by points near the left hand bottom of the trapezoid, Figs. 1 and 3, and the top of the producer is coolest when working with reactions near the right hand boundary (neutro-caloric line). The amount of hydrogen added to all other gas quantities will, therefore, vary in the diagram from place to place even for a given coal. This reasoning shows that, for the drawing of an absolutely correct gasification and distillation chart for bituminous coal, additional experimental data must be gathered. Even with such data at hand, the making of the chart will be difficult and tedious in the extreme.

In the before-mentioned publication, Claus and Neussel point out that interesting data can be gathered from the gasification chart for coke or anthracite. Fig. 7 was adapted from their publication without recalculation of the flame temperatures. The illustration shows that producer gas represented by the upper right hand corner of the chart gives the highest flame temperatures, while gas represented by the lower left hand corner gives no temperature rise whatsoever, —it being understood that all gases are cooled to room temperature before combustion. The chart also permits the reading of the producer or gasification efficiency (neglecting the heat in the steam) for any given possible gas analysis. The lines of constant efficiency are taken directly from Ostwald's book, p. 54. For gas produced from bituminous coal, lines of equal flame temperature, and of equal gasification efficiency can be computed, but the work is so slow and tedious as to deter anyone who is working solely for the enlightenment of his fellow citizens.

The man who has charge of gas producer operation will dismiss this whole discussion as purely academic and as one-sidedly theoretical, unless it helps him to so change the operation as to produce a better gas. With a given producer, and with a given gas demand, the following changes can be made in the operation:

1) Variation of steam supply.
2) Variation of air supply.
3) Variation of depth of ash bed.
4) Variation of depth of fuel bed.
5) Use of a non-clinkering coal, or else more frequent cleaning of the producer.

The present article is not a treatise on gas producers and upon their operation, and for that reason it will be impossible to go into details on the question of how a producer must be designed to furnish the best possible gas. All that can be done is to indicate on the chart (see Fig. 8) what the general effect of the different variations is. (This part is partly adapted from the publication of Claus and Neussel.) It would be intensely interesting to follow in the diagram the effects of more or less uniform steam and air distribution over the cross section of the producer, the effects of channeling by pokers, or the effect of deep ash beds upon the quality of the gas and upon the required pressure for blowing steam and air into the producer, but these problems are big enough to warrant a separate publication which should, by right, originate with one of the producer builders.

BRITISH IRON AND STEEL INSTITUTE.

The British Iron and Steel Institute will hold it annual meeting Thursday and Friday, May 4th and 5th, at the House of The Institution of Civil Engineers, Great George Street, London. The annual dinner will be held the evening of Thursday, May 4th, at the Connaught Rooms, Great Queen Street, London.

Members of the Iron and Steel Institute have been invited to participate in the next International Geological Congress which is to be held at Brussels in August, 1922.

During the Congress, excursions will be made to Quenast, to the caves of Han and Rochefort, to the cave and district of Remouchamps, to Liege, Spa and neighborhood, to the valleys of the Sennette and Samme, to Namur and the Samson fault, to Landelies, to the Tertiary Formations (Eocene) near Brussels, and to Louvain (Coal-mining Museum).

Description of Test on Furnace Sand

Investigation of the Thermal Conductivity of Sand—Practical Values for Use by Furnace Designers—Description of the Apparatus Used.

By M. W. MAWHINNEY
Assistant to Prof. Trinks, Carnegie Institute of Technology

THE matter of the conductivity of sand at high temperatures has long been a doubtful factor in the calculations of the designers of muffle furnaces and other furnaces where sand is used in the construction. In an attempt to improve this situation, the following test was devised and performed to furnish some guide to assumptions in the future. With the apparatus at hand, it was not possible to perform an extremely accurate test, but it appeared that if a reliable comparison could be made between a specimen of sand and of ordinary firebrick under the same conditions, the results would be of sufficiently practical value for furnace design. This method was therefore selected, and the apparatus designed accordingly.

Description of Apparatus.

The details and arrangement of the apparatus are clearly shown in Figs. 1 and 1a. The furnace used for the test was a Tate-Jones gas fired type, having a heating chamber about 18x14x7 in. The door was removed and the apparatus fitted into the opening in the brickwork. The apparatus itself consisted of a sheet iron container without top or back, the back being replaced by a wall of firebrick about 1¾ in. thick. The enclosed space was lined on sides and bottom with sheet asbestos to minimize heat losses and filled with the specimen of foundry sand tested. Sheet asbestos was fitted over the top, and the whole thing packed into the furnace opening with asbestos clay. The asbestos sheet is shown by the shaded portion of Fig. 1. The dot-and-dash lines are the outlines of the furnace proper, and show the relative position of the apparatus

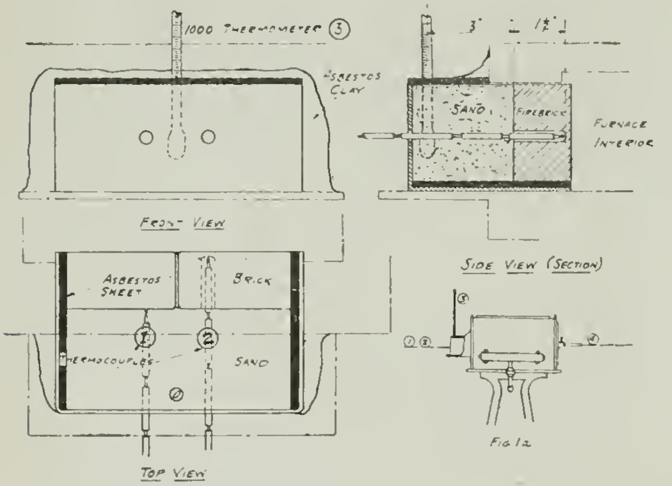


Fig. 1.

Investigation of the Thermal Conductivity of Sand.

Temperature measurements were taken at four places, three as shown on Fig. 1, and the furnace temperature with a pyrometer located as shown on Fig. 1a. All pyrometers used were platinum-rhodium couples. One is a pyrometer located in a hole bored in the brick 1½ in. deep from the junction of sand and brick, and to within ¼ in. of the surface of the brick inside the furnace. Two is a pyrometer placed just at the junction of the sand and brick. Three is a thousand degree thermometer 3 in. from the junction and ½ in. from the surface of the container. Four is a pyrometer contained in a silica tube and placed in the interior of the furnace.

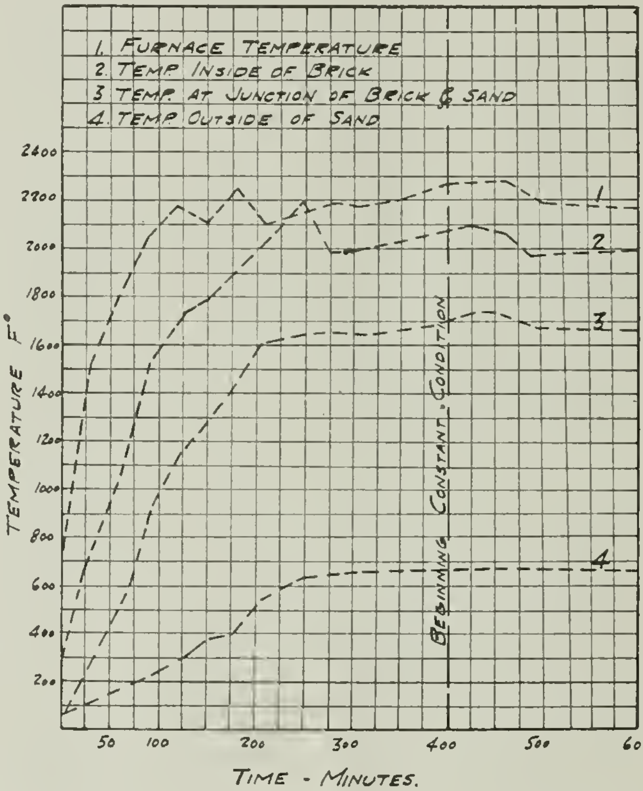


Fig. 2.

Performance.

The temperature of the furnace was brought up gradually to about 2200 deg. F., and kept as near this temperature as possible for about eight hours to insure a steady flow of heat through the brick and sand. Temperature readings were taken every half hour throughout this period. At the conclusion of the test all of the instruments were carefully calibrated.

Results.

Fig. 2 shows the variation of the temperatures at the different points with time. From a study of the curves it appears that the flow of heat became constant during the last four hours of the test. Averaging the temperature readings at the different points over this period, we find that the average temperature at the inside of the brick was 2029 deg. F., at the junction of the brick and sand 1689 deg. F., and at the outside of the sand 668 deg. F. Therefore, the temperature drop per inch through the brick equals $\frac{2029-1689}{1\frac{1}{2}} = 227$ degrees, while the temperature drop through the sand equals $\frac{1689-668}{3} = 340$ degrees per inch.

Now, assuming no heat loss through the sides (and this is reasonable as those surfaces were practically cold throughout the test) the conductivity will be inversely proportional to the heat drop. Therefore, $\frac{\text{conductivity of sand}}{\text{conductivity of brick}} = \frac{227}{340} = .67$ between 700 and 1700 deg. F.

Selecting an average value of 9 Btu. per sq. ft. per deg. F. per inch thickness for the thermal conductivity of firebrick, the conductivity of sand obtained from this test is about .67 × 9, or 6 Btu. per sq. ft. per deg. F. per inch thickness.

That this is but a rough constant for practical use only can readily be seen from a study of the conditions. In the first place, the value is only an average between the temperature limits of 700 and 1700 deg. F. Also the fact that the brick was heated to incandescence throughout, and part of the sand also became red hot would indicate that the factor of radiation also had some disturbing effect. However, since the conditions in the test were approximately the same as those met in furnace practice, the value obtained will serve as a guide until more accurate investigations are undertaken.

The Electric Furnace Situation

Dealing With the Widening of the Sphere of the Electric Furnace's Operation—One of the Most Interesting Developments Is That of Making Cast Iron in the Electric Furnace.

OBSERVATIONS on the existing status of the electric furnace and predictions on its future application have periodically appeared in the technical press with at least annual frequency. The majority of these publications have been more or less statistical, showing the electric furnace's position in the metal industries by the increase in the number of installations. There is quite sufficient evidence in every quarter of the country to establish the claim of the electric furnace as an accepted and standard type of melting apparatus. It has arrived at such a status by sheer force of its inherent merit and metallurgical flexibility, and further, in spite of a certain amount of misdirected effort and application, faulty and freak design, unintelligent experimentation, and super-enthusiasm of some of its most ardent proponents. But it is standard now and certainly bids fair to remain so and to be accorded even greater favor. Due to the low tide of production of practically every sort, particularly the metal industries, a comparison of the increase in number of installations in the past year to that in the three or four preceding years is by no means correctly indicative. But it should be pointed out that in comparison to the average of business generally the electric furnace undoubtedly has done a larger percentage of a normal year's business than any of the steel or iron industries. The electric furnace has done almost half a normal year's business in 1921, which is in reality an actual gain over preceding years. But a more important phase of the situation is the widening of the sphere of the electric furnaces' operations with which consideration this article is most directly concerned.

The electric furnace as a general term is a pretty comprehensive one and its development is a rather wide subject. These remarks are confined to its applications on the ferrous metal fields. But even this one class of applications, the electric furnace is unique in that it has gone into every branch of the iron and steel industry. The cupola has hitherto been supreme in the cast iron, the air furnace in malleable production, the Bessemer and the open hearth in the steel castings and rolling ships, and the crucible in the tool steel. So it has previously been the case that each type of steel or iron shop had a special type of melting. The electric furnace is in strong contrast with these other types of melting equipment because it has been successfully utilized in every one of the various types of iron and steel working industries.

Malleable Iron.

In the malleable shop, the greatest tonnage has been produced by the Kranz triplex process. This process utilizes a very large percentage of scrap, using the converter to reduce carbon and manganese after melting in the cupola. Sulphur is then reduced and the metal superheated in a basic hearth electric furnace. Another feature of this system is the ability it possesses of holding a charge at a constant analysis and temperature. The main objection to this is the floor space and capital tied up in the three types of equipment necessary. To cold melt a charge of scrap steel and iron adjusted to give a proper carbon and silicon content for a malleable specification in a basic hearth is not satisfactory for the reason that little or no reduction of manganese takes place, while almost total desulphurization occurs. The sulphur-manganese balance is thus not secured. It is, therefore, not highly probable that malleable will ever be extensively synthesized by the basic hearth electric.

Experiments have been made with the acid hearth electric with full charges of cheap steel scrap which indicate that a very excellent malleable specification can cheaply and almost automatically be obtained by this method. Several companies have been investigating this method and the next year will in all probability see some installations of this nature made. It is also very probable that the acid hearth will find greater favor in the malleable field than the basic. Combinations of the two will probably be worked out also.

Steel Casting.

So much has been written about the metallurgy and quality of electric steel castings that no attention will be given it here, and the superiority of it for this type of work is considered accepted. But for the production of very large steel castings the open hearth is still firmly lodged in its position. However, shops specializing in this large work usually have to take a certain amount of small work along with the large patterns and its production from the big open hearth heats is quite a difficult matter. The steel for this big work is of necessity tapped too cold for the small stuff so that the small casting production is usually a losing game. And years like the present one place these people at a disadvantage. The work which is secured is not sufficient in volume to keep the open hearth busy and the shop equipped with the average size of open hearth to be found in the steel castings shop finds itself in a position where they face shutting down or making two or three heats a week, keeping the furnace hot the rest of the time. Either of these courses of action is highly undesirable, the one resulting in the loss of a certain percentage of clientele and the other in a loss of a certain amount of money. These people are resorting in several cases to the expedient of installing a small electric furnace to take care of the small work during periods of active business and all production in slack times. In doing this the open hearth shop also finds itself in positon to take on a very much larger tonnage of small work than the cold melting electric equipment would allow. This they can accomplish by taking a duplexing heat from the open hearth when it is tapped and giving it in the electric, the temperature necessary for pouring small work.

Alloy Steels.

In the alloy steel industry, there is a very interesting development in the past year, in that, so far as cost is concerned, the alloy steels, once providing the strongest impetus the electric furnace ever received, have temporarily reversed themselves. This condition is due to several developments coming out of the business depression. During the past period of expansion and prosperity, the demand for alloy steels for ordnance and automotive uses got beyond all proportions of the country's productive capacity. The price was accordingly very high, in common with that of the ferro-alloys, fuel, etc. The rise in power rates was much slower than the prices of other commodities entering into the cost sheet. The saving in the alloys recovered, grade of scrap available for electric furnace utilization, but not available for open hearths, difference in price between this scrap and heavy melting steel, and other materials dictated the use of the electric furnace, resulting in a greater expansion than any other type of steel melting equipment has ever had in the same time, in point of installation numbers. With the decline in prices of fuels, alloys, etc., came no corresponding decline in power rates, these latter being under state regulation and consume, in effecting changes, a great deal more time than commodities, the prices of which operate under the law of supply and demand. The consequence of this has been that the past year has seen by far the majority of the automotive steels melted in the open hearth by the people who were open hearth equipped, and sold at a price much lower than the open hearth people liked to work on. This condition is an artificial one, just as the condition where electric furnace operation was so out of proportion was artificial. With the gradual return to normal conditions the production of alloy steels, which have been called electric furnace steels, will revert in a large degree to electric furnace production. In what degree or percentage is a question as answerable as when will business be good, and also one to be decided from time to time by recourse to pencil and paper and cold arithmetic, the matter of electric steel's superiority over open hearth steel being duly taken into account. But it is quite certain that during the year of 1922 a greater percentage of these "electric furnace steels" will be electric furnace melted.

The type of operation will also be decided by cost, i. e., where melting can be more economically accomplished by fuel, the scrap will be fuel melted and electrically alloyed and refined. Various combinations have been worked out, and it is quite possible that duplexing will have a wider use than in the past. Triplexing will always very probably be confined to works with blast furnace and equipment.

Tool Steel.

In the tool steels it is very probable that the electric will slowly but surely continue its encroachments on the crucible. With the increased knowledge of the art and the higher type of intelligence doing the actual melting work, better judgment in designing charges and carrying out furnace operation are overcoming the prejudice in favor of crucible steel. Poor workmanship on electric furnace operations has caused a great deal of poor grade tool steel to be turned out, which suffered in comparison with the crucible product. But the *active* refining tendency of electric furnace metallurgical conditions, when properly used, enable the electric furnace product to be much freer from inclusions than the cupola. This has been clearly demonstrated in at least one plant during the past two years.

Another interesting development of the art during the past few months has been the advent of an acid electric tool steel. The company manufacturing this steel states it is superior in many ways to the basic electric steel. This company is in fair position to give an opinion, operating as they do, a basic electric furnace.

In the production of steel the electric, even with a high power rate, will always be cheaper than the crucible product in manufacture, owing to the cost of the pots.

Cast Iron.

Of all the recent electric furnace developments, probably the most interesting and, from the trade's standpoint important, is its encroachment in the field of the cupola. Starting out, as the electric furnace die, in the tool steel industry, and as before mentioned, obtaining the greatest impetus in the alloy steels, both of which are the most expensive type of iron metals, in the year in which something of a recession has been noted in the electric production of these materials, the electric furnace has seen its largest gain in the manufacture of lowest priced iron metal, cast iron. This field is one in which the electric furnace will in all probability find its greatest expansion in the next few years. From the cast iron foundries alone, during the past year there have been upwards of a thousand inquiries to electric furnace manufacturers. This amount of inquiry evidences a very decided amount of interest.

Electric cast iron has been extensively advertised in the form of piston rings. Duplexed iron has also been utilized for valve castings during the last few years. These parts are rapidly assuming the same rate in the iron field that the alloy steels have played in the steel shops, i. e., essentially an electric furnace proposition. In time, it is also very highly probable that chilled rolls, cylinder liners, cylinders, automobile valve seats, glass bottle moulds, and various other parts now either cupola or air furnace cast, will enter the "electric iron" heading, just as chilled rolls have already largely done in Sweden.

But, during this year, one of keen competition and falling prices, the country has very probably for the first time seen a foundry shut down its cupola and turn its iron into the electric for primarily pure economic reasons. The Queen City Foundry Company has done this and have, while improving the quality and control of their iron, used scrap and cut their costs. Locality, of course, plays a certain part on such a condition, but such a condition is not peculiar to any one major section of the country, and is decidedly operative from the Rockies West, as well as many localities such as Chicago and other industrial centers. This condition will, of course, be narrowed as the practice of charging cheap scrap into electric furnaces gains more popularity. But such a condition cannot be adjusted further than the point where the margin between scrap and pig isn't sufficient to allow the difference in cupola and electric furnace cost. The demand for such scrap would then fall off, pig being then purchased.

There are one or two points in the electric metallurgy of cast iron which are still mooted questions, but the claim that borings in full charges cannot be completely melted in stationary or non-oscillating types of the direct arc furnace is not substantial. Complete charges of borings can be melted in the direct arc iron oscillating furnaces of at least two types, with practically the same power input as for heavier charges, and for about 10 per cent less power input than is averagely obtained in the indirect oscillating type furnace. This has been accomplished on numerous occasions.

An example of one type of control obtainable in the electric furnace is hardness. In a foundry making glass bottle moulds with a 500-lb. electric furnace, before heats were tapped, a test bar is poured into a dry sand mould. It is left a certain length of time in the sand (about three minutes) and then allowed to air cool till black, which takes about seven minutes. The bar is then water quenched, broken, one end ground and Brinelled. Very accurate hardening results are obtained by making such additions to the bath as are necessary. This is in itself quite an innovation in the iron foundry in this country.

As an indication of the diversity of uses of the electric furnace in the iron foundry, there are at present the following wide variet of electric furnace iron castings now produced in the states: Piston rings, locomotive cylinders, grate bars, valves, large and small, ball mill chilled liners, soil pipe and fittings, sewer gratings, high pressure steam fittings, glass bottle moulds, etc.

In all situations the ratio between power rate and scrap pig and pig and coke cost have to be the deciding factor in the economics. In some instances economies are not major considerations, being subordinate to the quality factor, but as above mentioned, power rates are lagging behind the price trend in other commodities. These will, of course, in time, in large part, be adjusted. But at least two instances have been carried out to a final stage and resulted in the decision that electrical furnaces are a preferential load and are therefore entitled to a preferential rate. A precedent of this sort is a very important one, and one of the companies isssuing such a preferential electric furnace schedule had seen the advantage to their business of electric furnace loads and actively solicits such loads. More of this sort of action will, of course, result to benefit the central stations, power consumers and furnace manufacturers.

The electric furnace has had a phenomenal growth, with, be it said, the usual youthful maladies. It has survived, however, and its maturity promises to be even better than its adolescence.

Roller Bearing Mill Tables

A Description of New Rolling Mill Tables in Which Were Installed Flexible Roller Bearings—International Nickel Company Among Prominent Users.

By J. M. KELLY
Engineer, Hyatt Roller Bearing Company

THE reliable performance of the flexible roller bearing on mill table equipment is becoming more and more pronounced, and during the year 1921 additional rolling mill tables have been designed and built with the flexible roller bearing incorporated on the table rollers and side shafts.

The International Nickel Company, Huntington, W. Va., will soon place in service a 24-in. sheet bar mill, and for a length of 260 feet the approach and runout tables will operate with Hyatt roller bearings. This mill was designed by F. I. Ellis, consulting engineer, Pittsburgh, Pa., and these auxiliary tables were built by the Connellsville Foundry Machine & Steel Castings Company, Connellsville, Pa.

The 24-in. sheet bar mill recently installed at the Mansfield Sheet & Tin Plate Company, Mansfield, O., includes flexible roller bearings on 400 feet of table. This mill was designed by F. I. Ellis and Barton R. Shover, consulting engineers, Pittsburgh, Pa., the table equipment being built by the Woodard Machine Company, Wooster, O.

The 12-in. diameter table rollers for these mills are supported in the bearings in the manner indicated. The bearing housings are bolted to the 10x1½-in. slabs and the opposite bearings on the same table roller are aligned accurately.

The bearing housing is in two parts, the top being fastened to the base by bolts.

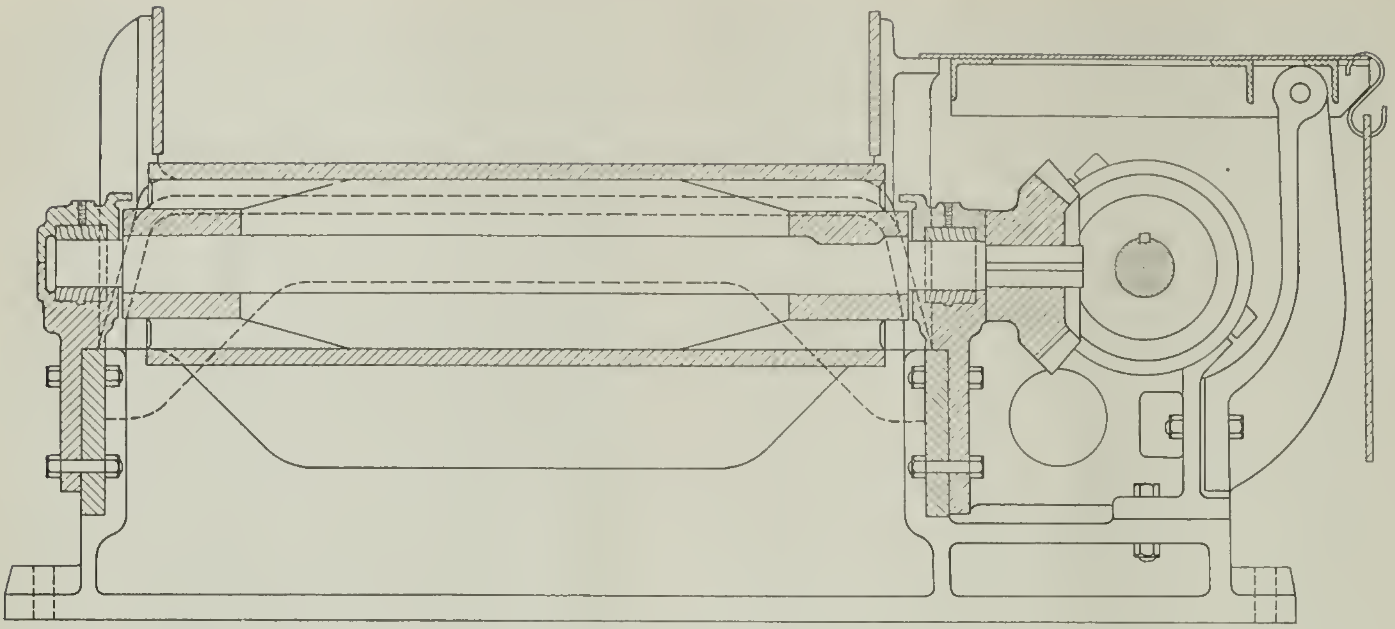


Fig. 1—Design of Hyatt equipped approach and runout tables for 24-in. sheet bar mills at International Nickel Company and Mansfield Sheet & Tin Plate Company.

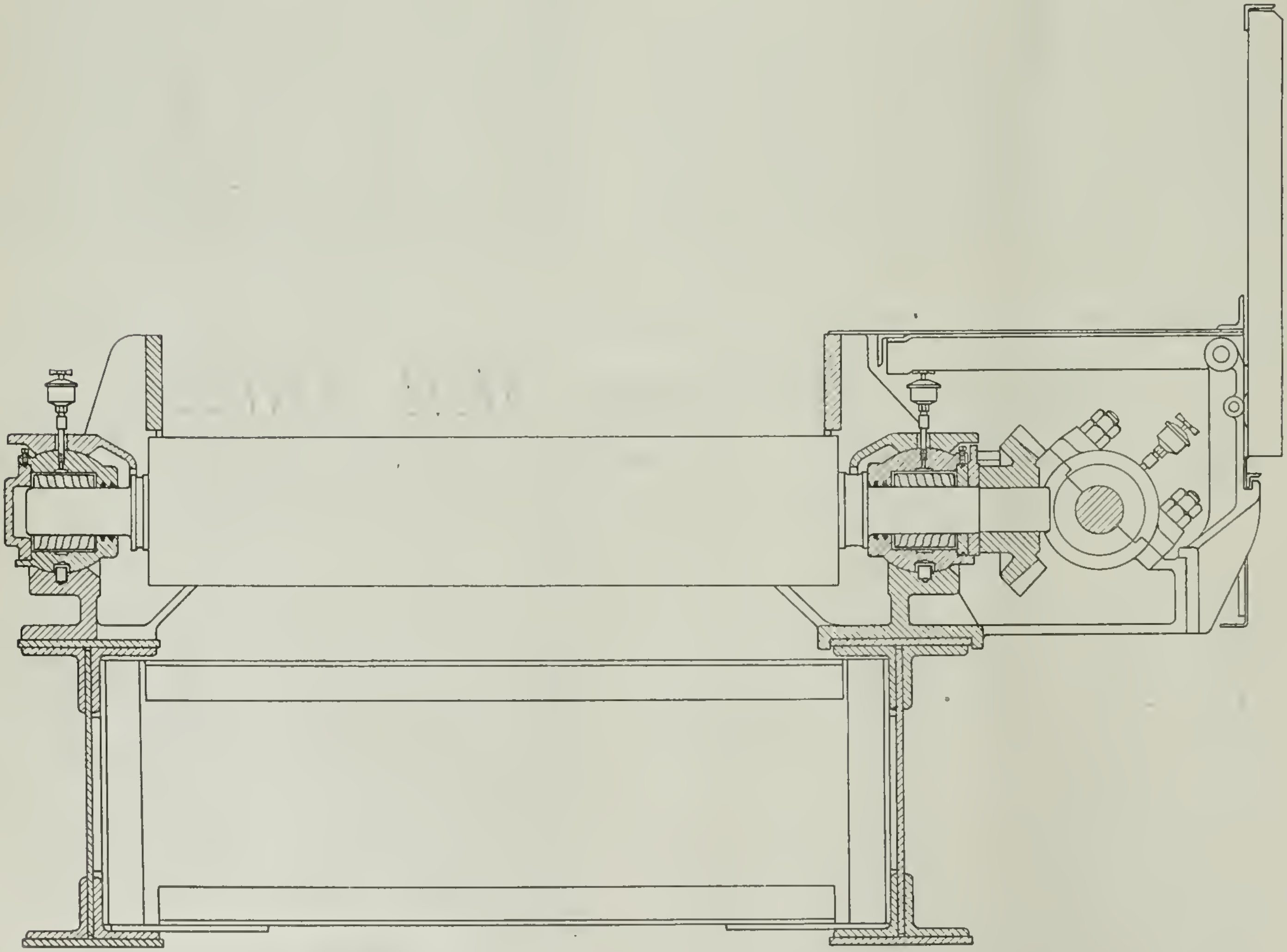


Fig. 2—Design of Hyatt equipped table for 28-in. structural and bar mill for Acieres De Micheville, France, similar to tables now in successful operation for two years at Tennessee Coal, Iron & Railroad Company.

To the many mills designed and built by the United Engineering & Foundry Company, Pittsburgh, Pa., and already in operation with flexible roller bearings incorported on all table rollers and side shafts, this company has added during the past year a flexible roller bearing equipped table for the 28-in. structural and bar mill to operate at Acieres De Micheville, France.

The construction as shown is identical with the installation that has operated for the past two years on the 28-in. combination structural and bar mill at the Tennessee Coal, Iron & Railroad Company, Fairfield, Ala.

This construction of the table roller and flexible roller bearing journal boxes is also similar to the installation on the 35-in. blooming mill main lifting tables at John A. Roebling's Sons Company, Trenton, N. J. This 35-in. blooming mill was built by the United Engineering & Foundry Company and has been in service for 2½ years.

The roller bearings are enclosed in journal boxes which are self aligning, being spherical on the outside and set into spherical seats both in the cap and in the table girder.

The Gary works of the Illinois Steel Company, Gary, Ind., will shortly place in service a 12-in. strip mill and a 20-in. strip mill. The approach and hot bed tables of these two mills are completely equipped with the flexible roller bearing mounted in the self-aligning, ball-seated journal boxes which have proved a decided advantage on mill table equipment.

Flexible roller bearings have been incorporated in the table rollers and side shafts of a pronounced majority of the mill tables built during the past five years. The use of flexible roller bearings is of material advantage to operating men, inasmuch as the serious delays often caused by inferior bearings are entirely eliminated and the bill is not held up for table bearing repairs.

Master mechanics have pronounced the flexible roller bearing to be the correct type of bearing for mill table equipment on account of the decreased maintenance necessary, not only on bearings but also on other vital parts, such as gears. With these bearings mounted on the table rollers the gears are held in mesh and alignment, which is extremely important with bevel gears.

The slight increased cost, which is sometimes necessary to incorporate the flexible roller bearings, is offset by the advantages:

Advantages of Roller Bearings on Mill Tables.

1. Saving in power.
2. Smaller motor, which offsets, partly, the higher cost of the bearings over ordinary ones.
3. Since there is practically no wear, the gears remain in alignment, which is very important with bevel gears.
4. Saving in oil.
5. Saving in attendance.
6. No spilling of oil, therefore cleanliness and no danger from fire.
7. Cost of repairs is reduced both on bearings and on gears.

Sheet and Tin Mill Furnaces

Many Improvements in the Furnaces Used for Heating and Annealing Sheet and Tin Have Been Made During the Past Few Years.

By T. J. COSTELLO and J. H. KNAPP

SOME people outside of the sheet and tinplate industry and a few of the younger ones engaged in the trade are under the impression that the manufacture in this country of sheet and tinplate dates back to the days of the McKinley tariff bill of the late '80's, but this is only true of tinplate; iron sheets were rolled in this country about two generations previous to the passing of the McKinley tariff act.

Previous to 1885 sheets were rolled from iron produced in the puddling furnaces and the knobbling or charcoal fire; these sheets were of a very high rust resisting quality.

The method of rolling iron sheets was practically the same as that in use today with the exception that the machinery and power required for the purpose were much lighter, as for example, the rolls of the iron rolling period were 20 inches in diameter against the rolls in use today of 30 inches in diameter for rolling steel sheets.

The tonnage of steel sheets per mill today is about three times that of iron sheets produced on the lighter equipment in the puddle iron days.

As in every other field necessity brought about the few changes that have taken place in the sheet rolling equipment, as it was soon apparent that the production of steel sheets called for heavier machinery and better furnaces. About 1905 there was a bold effort made by one of the principal sheet and tinplate manufacturing companies at Sharon, Pa., to revolutionize the process by semi-continuous rolling. This method did not prove satisfactory and was abandoned in a few years, although there seemed to be considerable merit in the process for rolling the heavy gauges at least.

Previous to 1890 many mills produced sheets sufficiently flat for the requirements of the trade at that time without the use of cold rolls, and some of them several years after the above mentioned date.

The automobile and furniture trade, which at the present times take a large part of the total sheets produced, require, however, what is known as full finished stock. This makes the cold rolling department a very important part of the operation, also the furnace and method of heating these highly surfaced sheets is of great importance, so much so that there are a number of mills in the country that do not undertake to roll this class of sheets, principally on account of their inferior furnace equipment.

The stamping and deep drawing of steel sheets is another branch which requires special attention to heat treatment, it having been found that box annealing is not entirely satisfactory for this grade of sheets. The result of these new demands upon sheet steel manufacturers has naturally called for the advice of the metallurgists who in many instances have traced most of the difficulty to the design of the furnaces and the method of heat treatment. About 10 years ago improvements in the furnace equipment first started and since that time there has been more progress made in sheet and tinplate furnaces than in three generations prior to that date.

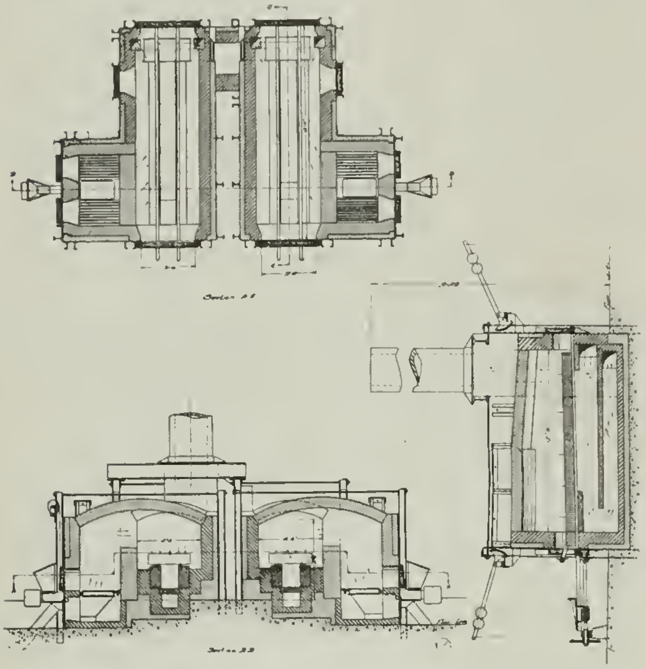


Fig. 1.

The furnace equipment in the early days of the industry was, of course, hand fired and hand charged, being very wasteful in fuel and none too satisfactory in proper heating. The first step toward fuel saving was the Bailey combination sheet and pair furnace where the sheet and pair chambers were built in a block, using a common fire box, the pair chamber being behind the sheet chambers and between the sheet chambers and the fire box.

While this unit was a fuel saver, it had many disadvantages, the main one being that fire must be generally controlled to satisfy the sheet chambers and therefore the pair heater must go along as best he can and in most cases this does not result in very satisfactory heating of the pairs, generally causing excessive scaling and non-uniformity of heating.

While the reheating of the sheets does not readily lend itself to a continuous heating operation, the heating of the pairs does and the first step in the direction of a continuous unit for giving a clean and more uniform heating of the sheet bars was the Allis continuous pair furnace. This furnace was put in operation at Middletown, Ohio, by the American Rolling Mill Company in 1911 and since that time it has been adopted by a great many modern sheet and tinplate plants. While about even with the hand charged furnace in fuel consumption, the first cost, floor space required and maintenance cost seemed to outweigh its good points with many manufacturers. In the Allis continuous furnace the sheet bars were pushed through the furnace lengthwise, lying in grooves on a cast iron bottom.

The next improvement in furnaces for heating pairs continuously was the Costello continuous pair furnace. This furnace developed about three years ago and was first put into operation in August, 1920, at the plant of the Superior Sheet Steel Company, Canton, Ohio. In this continuous pair furnace the bars are pushed through the furnace standing on edge and they travel on skids made of 3-inch round merchant bars. Fig. 1 shows sectional views of one of these furnaces. It will be noted from the cut that the gases travel over the top of the sheet bars, reach the end of the furnace and then double back and pass through a flue underneath the bottom of the bars, the bars themselves acting as the dividing wall between the two gas passages. The burrs caused by shearing the bars and the unevenness of the bars themselves act as spacers which hold each bar slightly away from its neighbor. This gives a slight space which allows gas to percolate through between the bars and gives a very uniform heat without scale.

The use of the furnace gases both on top of and underneath the bars, giving twice the travel to these gases in contact with the material before they leave the furnace greatly decreases the fuel consumption, also the pushing of the bars through on edge makes possible a much smaller heating chamber for the same tonnage as compared with the Allis furnace. This again means a saving in fuel.

Due to the smaller chamber size and the details of construction the first cost of this type of continuous furnace is very little more than the first cost of the old type hand charged unit; the floor space is considerably less and the upkeep or maintenance is exceedingly small, the actual expense per furnace having run $150.00 per year.

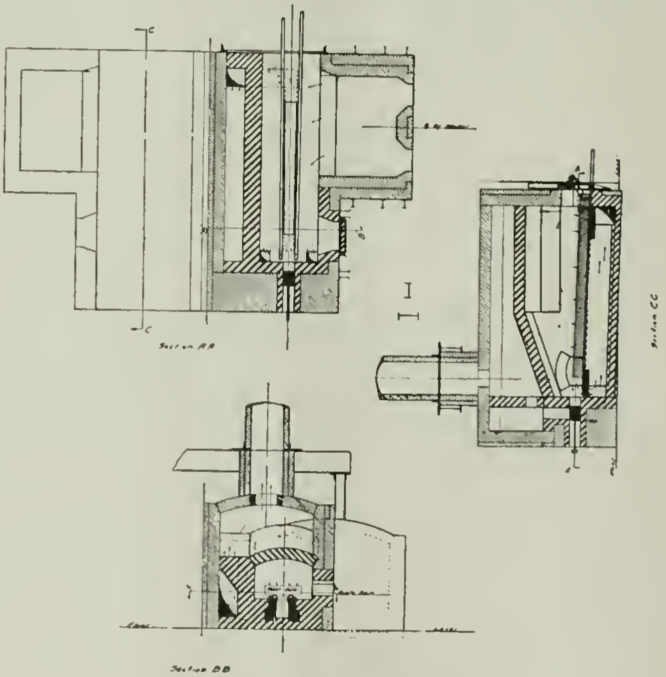
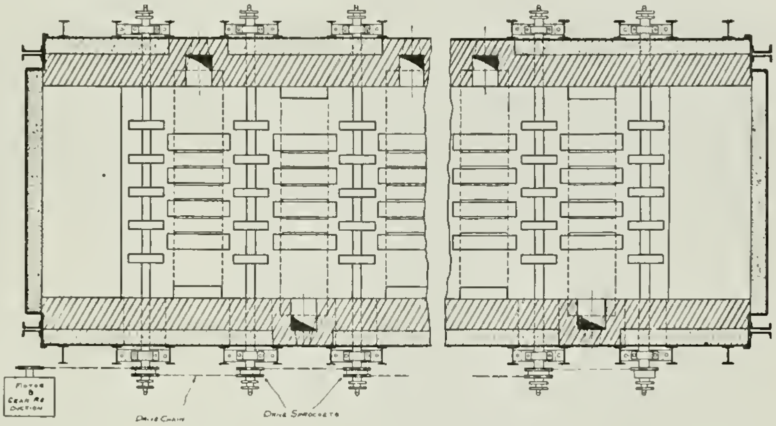


Fig. 2.

An interesting fact in regard to this design of continuous pair furnace is that it can in some cases be readily built in side of the present hand charged or continuous furnace at very little expense and without tearing down the present furnace equipment; this is due to the much smaller hearth area required for this furnace and to the method of charging and discharging the bars. Fig. 2 shows a view of the Costello continuous pair construction built inside a continuous furnace of another type. The heavy section lines show the new brick work and the lighter lines the original furnace.

As an example of this is a layout of one double chamber continuous pair furnace and two double chamber sheet furnaces in a floor space 42x48 feet. This is the furnace equipment for two mills and this arrangement saves one complete 20-foot bay of a building over any other continuous or hand charged types. This means that in an eight-mill plant four bays or 80 feet of foundation, 80 feet of bedplate and 80 feet of spindles, which naturally total to quite an item in the first cost of a new mill, are saved. This furnace has proved itself very economical as to fuel consumption and on hand fired units, in an eight-mill plant, shows a fuel consumption of from 175 to 225 pounds of coal per ton depending on the tonnage and the gauge being rolled. A three months average for both sheet and pair heating, taking in light and heavy gauges, showed a total consumption of 385 pounds per ton of finished product from both the sheet and pair furnaces, and as sheet furnaces were of standard type this low figure was due to the economy of the pair furnaces.



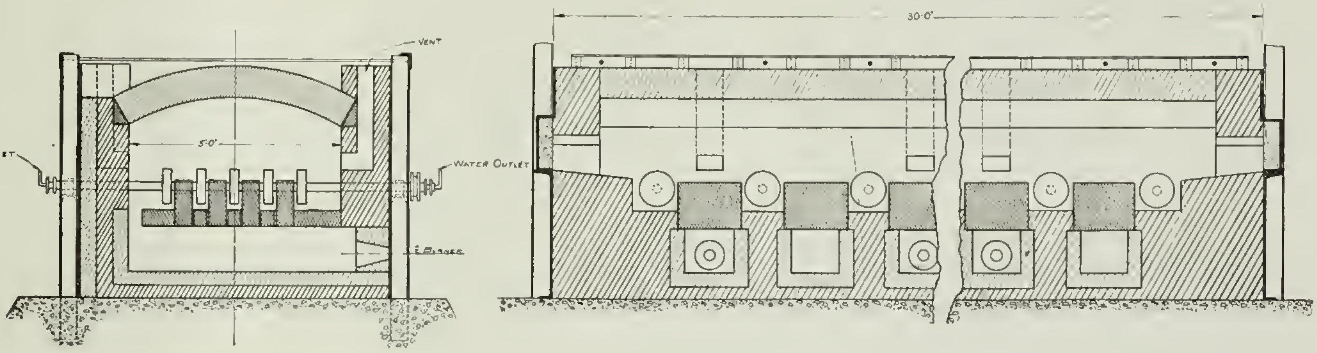


Fig. 3.

Insulation of sheet and pair furnaces seems to have been entirely disregarded, but as fuel economy becomes more and more important the insulation of sheet and pair furnaces is an item which will not be overlooked by up-to-date plant managers.

In the Costello continuous pair furnace a layer of 2½ inches of high grade insulation over the main arch results in a saving of fuel of about 30 pounds of coal per ton of sheet bar heated, when the furnace is operating on full tonnage of average size sheets. The saving on a sheet furnace, operating under the same conditions, would amount to about 8 pounds per ton, or a total of 11 pounds of coal per ton of sheets. The first cost of insulation generally looks high to the average sheet mill manager, but under ordinary conditions and average prices for material, labor and coal, the actual saving can be readily figured and it will be found that ordinarily the insulation of the arches alone on sheet and pair furnaces will have paid for itself in fuel saved in less than two years time.

On sheet furnaces there has been very little change in design or construction except in minor details. Due to the method of handling the material, a continuous furnace of any type seems an impracticability for this heating operation and therefore there are no considerable improvements that could be made in sheet furnace, although it is possible that some day a continuous sheet furnace will be devised that can be fitted satisfactorily into a mill layout.

After the pair furnace and sheet furnace, we come to the annealing operation or the final heating operation on the sheets. The great bulk of sheet steel made in the country today is annealed in boxes and, depending on the finish desired, gas muffled or not. The annealing of the sheets in boxes is an operation which lends itself readily to a continuous furnace where the production is fairly constant of the same size and tonnage of sheets as in the tinplate industry. In a number of the larger plants in this country continuous furnaces have been installed for this work. In the sheet industry, however, where the sizes vary considerably and the time element of differently charged boxes changes, a continuous furnace is not as readily adaptable, but in many instances could be used at a very great saving in fuel.

A large majority of the installations in the country at the present time, however, are the single or double box type furnace where the boxes are placed in the furnace, brought up to temperature and then allowed to cool. This naturally is wasteful operation as all of the heat required for bringing up the furnace itself is lost each time, whereas in a continuous furnace the heat required to bring the furnace up is only expended once and then all the heat used, except that lost by radiation from the furnace walls and through the fuel, is the amount required to heat the material.

About 15 years ago there were some experiments carried on in open annealing and while these were not entirely successful, they led to the designing early in 1913 of what is known as the Costello continuous open annealing furnace, three of which were installed by the Otis Steel Company, Cleveland, Ohio. Since that time many of the more modern plants that have been built have adopted this type of furnace for open annealing in connection with the jobbing mill.

The question of open annealing sheets in gauges from 16 to 24 is the latest problem which has been presented to the furnace designer by the steel plant metallurgists. It has been found that the box annealed sheets do not give the results desired—deep drawn stock, for some grades of automobile work and as what is necessary is not an annealing but actually a normalizing operation. Quite a number of plants are at the present time open annealing or normalizing sheets in gauges from 16 to 24 in furnaces similar to their present sheet furnaces and in fact in some plants this work is done in a sheet furnace. A continuous furnace for this work is entirely feasible and one of a very suitable design is shown in Fig. 3.

In this furnace the sheets are carried on discs made from special heat resisting alloy material as the temperature, required for some of the normalizing work, is higher than the point at which cast iron discs will stand up satisfactorily for any great time These discs are properly spaced and shaped so that the light gauge sheets will be satisfactorily carried through the furnace. This type of furnace is underfired, using either oil or gas as fuel. Combustion is complete in the chamber underneath the hearth of the furnace and the sheets receive their heat by radiation and convection from both the top and the bottom. An absolute control of the atmosphere inside of the furnace can be maintained so that there is no danger of oxidizing or scaling the sheets in the furnace. An automatic temperature control device can be satisfactorily applied to such a furnace so that it can be set for a desired temperature and this device without attention from the operator will maintain the furnace at the proper point and insure correct normalizing of the sheets. The time of treatment can be varied by the speed of rotation of the rolls.

As the most important changes and improvements in furnace design and practice have occurred within the last 10 years and as the industries are rapidly expanding undoubtedly still further development along these lines can be looked for in the future.

Description of a Pressed Steel Plant

Brief History of the Reorganization of the Sharon Pressed Steel Company at Sharon, Pa.—It Is Equipped to Manufacture and Assemble Heavy Pressed Steel Products—Routing and Handling.

THE Sharon Pressed Steel Company was organized in June, 1919, with an authorized capitalization of three million dollars in 7 per cent preferred stock and three million dollars in common stock, all having a par value of $100.00 per share. The company took over the properties and patents of the Hydraulic Drawn Forging Co. of Ellwood City, Pa., and purchased from the Blaw-Knox Company of Pittsburgh its modern plant at Sharon, Pa.

The Hydraulic Drawn Forging Co. had purchased from Follansbee Bros. of Pittsburgh a concern known as the Pressed Steel Truck Co., with patents and machinery for the manufacture of the "Atlas" line of pressed steel trucks, trailers and other equipment for industrial transportation.

The Blaw-Knox Company was a merger of the Blaw Construction Co. with plant and equipment at Hoboken, Pa., manufacturing steel concrete forms and structural steel, and the Knox Pressed and Welded Steel Co. located at Sharon, Pa., in the buildings now occupied by the Sharon Pressed Steel Co. Upon completion of this merger, in order to reduce overhead and consolidate production, a large part of the Sharon equipment was moved to the Hoboken, Pa., plant. Contracts were let to completely dismantle the Sharon plant when Messrs. McGill and McIntyre, with several other influential Sharon people, took steps to save the industry for Sharon. The result was the organization of the Slick-Knox Steel Co. which acquired the Knox plant at Sharon and took over at the same time the Hydraulic Drawn Forging Co. The plant of the latter concern at Ellwood City—which, during the war, was engaged in the production of air craft engine cylinders and forgings—was sold, and activities centered at the Sharon plant.

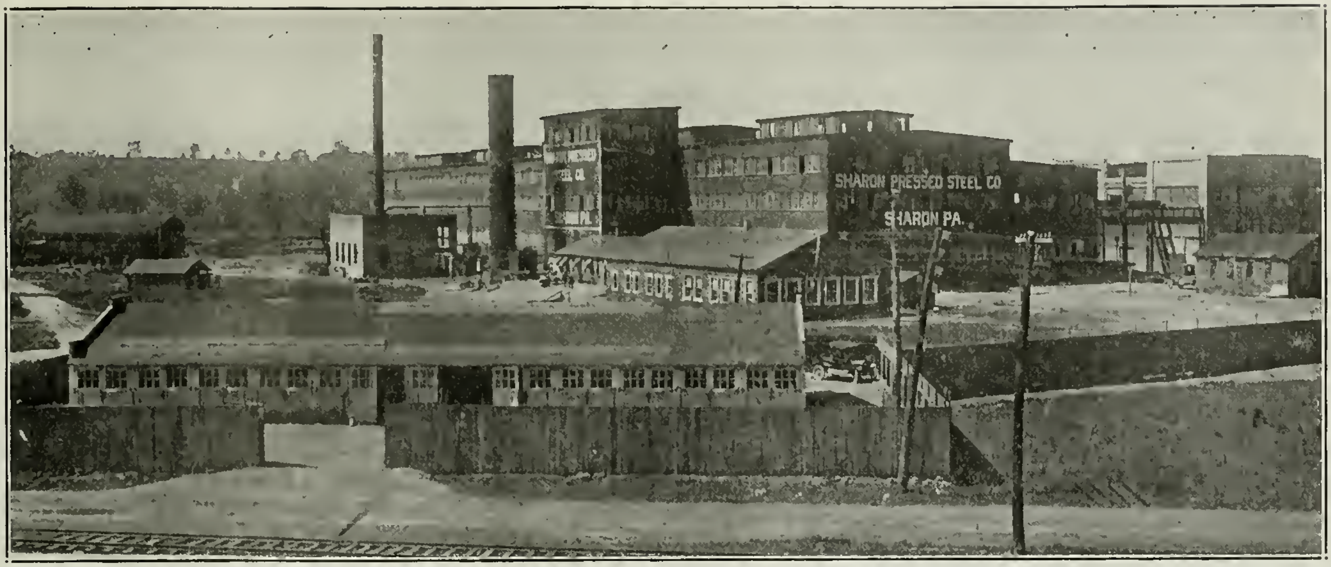
On March 1st, 1921, the Company was taken over for refinancing and reorganization by Messrs. Harry W. Torney of Torney and Co. Inc., Albert W. Morris, formerly of the Harley Co., and Arthur E. Swan, former works manager of the Crucible Steel Co.

Product.

The Company manufactures a complete line of heavy pressed steel products, including:—automobile and motor truck frames, brake drums, step hangers, torque arms, clutch discs, and other parts; pressed steel hand trucks, trailers, dead skids, and other specialties for industrial transportation; pressed steel car roofs, car ends, and journal box covers; and a great diversity of industrial parts and fittings in pressed steel.

Location and Geographical Advantages.

The plant is located at Wheatland, Pa.—a village on the southwestern edge of the city of Sharon—about 60 miles north of Pittsburgh and some 16 miles east of Youngstown, Ohio. This location, in the very heart of the steel producing district, is within easy reach of every source of raw material requisite to the Company's purposes. The lines of the Pennsylvania, Erie, and New York Central Railroads pass the property, providing every facility for quick shipment north, east, south or west. The character of the population of Sharon has enabled the Company to operate with American workmen selected for their skill, experience and intelligence, and unusually free from disturbing factors in labor matters.



View of the Sharon Pressed Steel Company at Sharon, Pa.

Property.

The property lines of the Sharon plant enclose an area of about 93 acres, every foot of which is economically available for factory purposes. The plant buildings, including manufacturing space and storage capacity for raw materials and finished parts, total approximately 30 acres in area. These buildings, while compactly grouped, are so placed that extensions and expansion can be had in four directions without sacrifice of efficient arrangement. The plant lay-out is designed for maximum production at minimum cost, by economical routing and labor-saving methods of handling work and materials. A siding entering the Company property from the adjacent railroad tracks has two branches—one entering the main building at the eastern end—the other skirting the main building and the assembly building at the western end, with a branch serving the scrap bins, boiler house and oil tanks.

Buildings.

The main building, housing the pressed steel and hydraulic forging departments, is of steel frame and corrugated iron construction. Its dimensions are 500 x 115 feet; and concrete piers are in place for an extension of 150 feet at both the north and south ends. The main span of 70 feet is served by three 5-ton and one 15-ton travelling cranes; the secondary bay, or lean-to, with a width of 45 feet, has a 15-ton travelling crane.

Immediately west of the main building, and separated from it by a storage yard 60 feet wide, is the machine shop housing the machine shop, tool making department, and hydraulic accumulators, pumps and air compressors. This building is of brick and steel construction, 250 x 75 feet, with Aiken type roof and travelling crane. The storage yard adjacent is also served by a 15-ton travelling crane.

The assembly building, 300 x 150 feet, lies south of the machine shop and joins the main building at its eastern end. This also is of brick and steel construction, with Aiken type roof, and houses the frame assembly and the department of industrial trucks, trailers, etc. It is paralleled on its southern side by a 30-foot concrete loading platform with railway track alongside.

In addition to these main structures, the plant includes the office building, boiler house, time-keepers' office, pattern shop and pattern storage and large garage. The Company has its own water supply system and sewage disposal plant.

Machine Equipment.

The plant is electrically driven throughout, power being purchased from the local public service entering the factory grounds at high voltage and being stepped down in the private transformer house. Every piece of machinery in the plant is driven by its own electric motor—an arrangement which minimizes delays due to any causes short of a complete failure of the power supply.

While space forbids a listing of the complete machine equipment, the following units are of outstanding interest because of their size; and they are indicative of the capacity of the plant for the largest and most diversified work in heavy steel pressing. Heading the list comes the 4000-ton Mesta hydraulic rail press—a unit designed and built for the Sharon plant and probably the largest press ever produced. Second in size and capacity stands the 1800-ton Kilby hydraulic rail press. Other notable units are:—a 1000-ton Southwark hydraulic press; an 800-ton Williams White rail blanking press and 18-ft. Shear; a 500-ton Southwark hydraulic press; a 250-ton Hazel hydraulic press; and a 125-ton Southwark hydraulic press; a 125-ton Ferracute crank press. Supplementing these heavy units are batteries of crank presses, shears, punches and power hammers in great variety and covering every possible requirement. Practically all of this equipment is housed in the main building.

In the machine shop there is an exceptionally complete lay-out of lathes, planers, drill presses, etc., specially adapted to the exacting work of tool and die making, as well as for the production of such machined parts as are included in the assembly of the pressed steel products which make up the factory output.

Routing and Handling.

Incoming stock is received and stored at the most advantageous points in the plant, being unloaded direct from railroad cars to storage space. Thence it is handled by travelling cranes throughout the plant along the shortest route and lines of least resistance, so that "lost motion" is eliminated, handling costs minimized, and production kept at top speed.

As the business is fundamentally that of manufacturing in quantity and delivering under stated schedules, the importance of efficient routing and handling cannot be over-estimated; and the plant is designed and operated to conform with these exacting requirements.

Inspection.

The major part of the output is made according to customer's specifications, and consists of a product not merely fabricated but completely assembled. Should a Sharon product be rejected and returned by the customer it is — generally speaking—a total loss except for its scrap value. Herein lies the explanation of, and the necessity for, the exceptionally thorough system of inspection in effect.

This inspection begins with a test of the raw material as received from the mill, to see that it conforms with specifications both as to chemical and physical properties. And from then on, through every stage of forming, machining, fabrication and assembling, every step is under the watchful eye of trained inspectors and every operation checked by the most careful standards. And to this painstaking care is due in large measure the high repute of Sharon products for uniformity of dimensions and quality, and for exact conformity with the customer's specifications.

Heat Treatment and Hardness Testing.

Many products—notably the automobile and truck frames—are given special heat treatment in order to assure the utmost in the way of structural strength and resistance to deterioration in service.

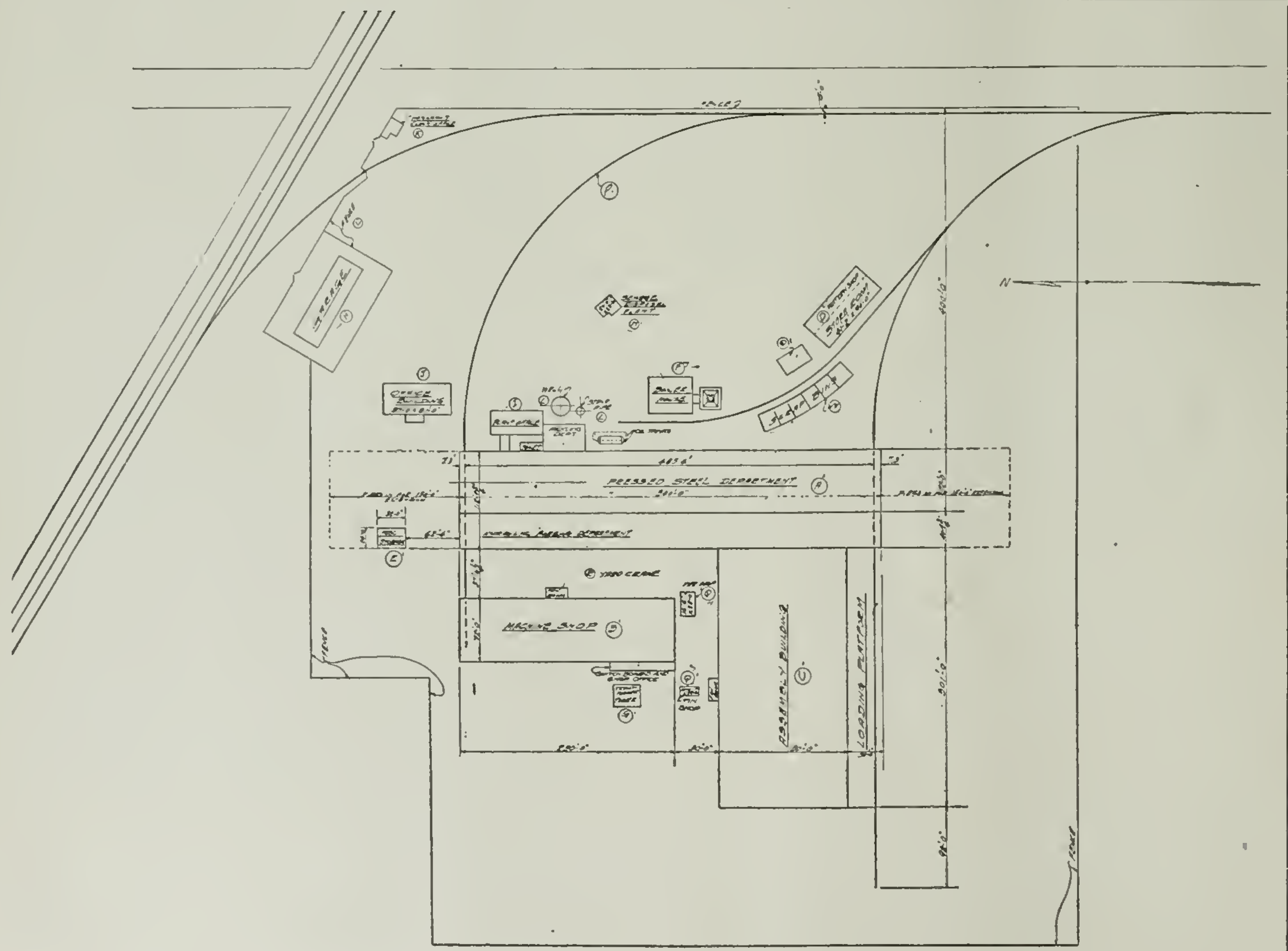
The steels used vary in their character according to customer's specifications. The processes of pressing, bending and shearing through which they pass give rise to internal stresses which, if not relieved, would materially alter the physical characteristics of the material and weaken the structure.

The function of heat treatment is to relieve these stresses and to restore the material to its original condition of maximum strength. While the process is simple in principle, it is made extremely complex in actual practice by the many variable factors determined by the character of the steel supplied and the processes through which it passes. Experts who have specialized in heat treatment know the proper temperatures and the proper times to be used, not only in the heating furnaces but in the quenching baths as well.

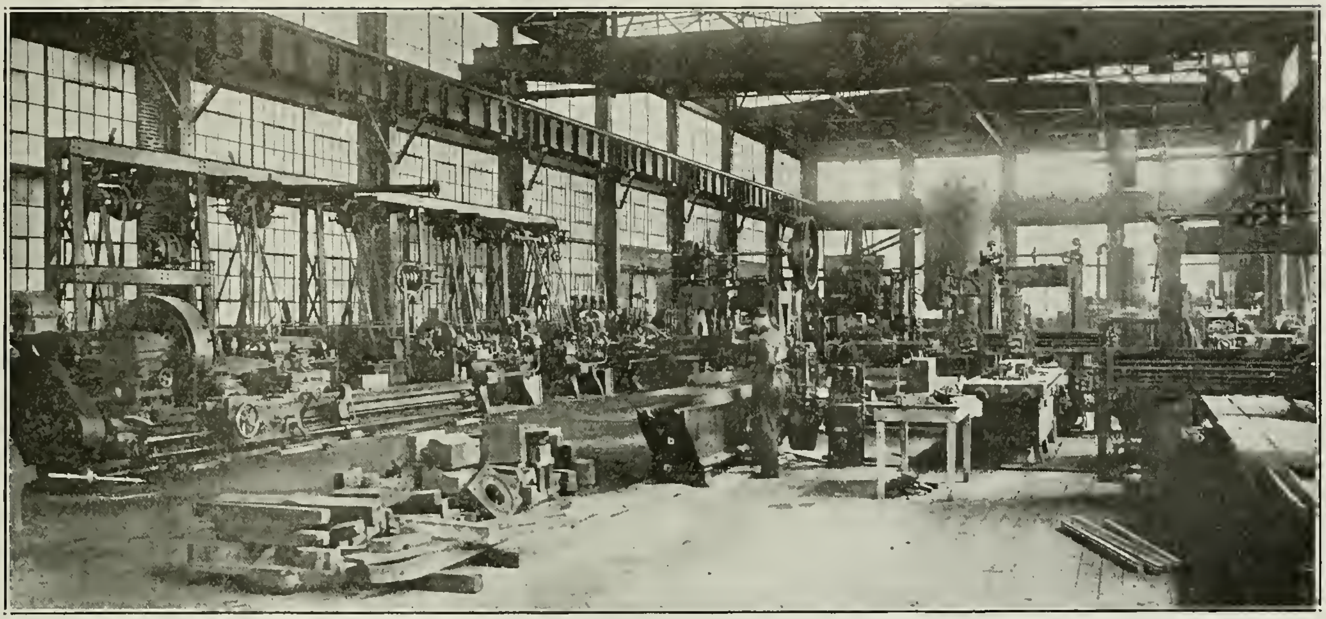
Where a certain standard of steel hardness is called for in the specifications, every piece of steel is tested before assembly, by means of a scleroscope; and the reading is marked on the piece or recorded for future reference.

Factory Organization.

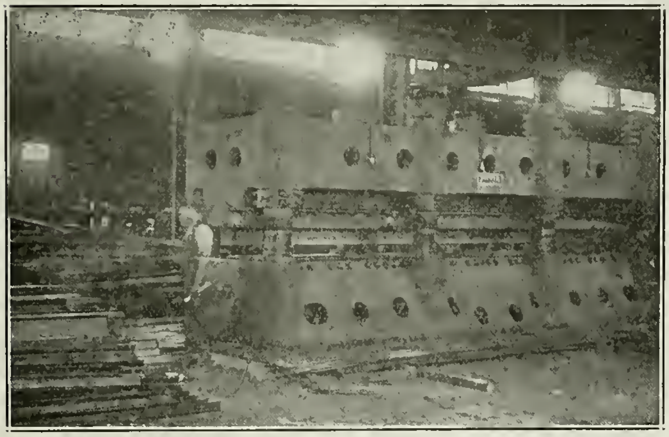
The following brief outline of the departmental organization may be of interest—the functions of each



Layout of pressed steel plant showing location and arrangement of various departments.



The machine shop of the Sharon Pressed Steel Company is exceptionally well equipped. Each piece of machinery is driven by its own electric motor.



A 4,000-ton Mesta hydraulic rail press, especially designed for this plant. It is probably the largest press ever produced.

department being fairly indicated by its name:

Drafting Department.
Purchasing Department.
Materials Department.
Production Department.
Tool Department.
Machining Department.
Die Storage.
Pressed Steel Department.
Inspection Department.
Heat Treating Department.
Pattern Department.
Maintenance Department.

The present organization includes:

H. W. Torney of Torney & Company, President; A. E. Swan, General Manager; W. A. Groetzinger, Assistant General Manager; T. A. Pierce, Assistant Treasurer; R. B. Reid, Sales Manager.

The working organization of the plant is headed by H. W. Zellman, who was formerly with the Hydraulic Pressed Steel Company, and who is general superintendent of the plant.

J. Curtis is superintendent of Pressed Steel Dept., and Herman Miltenberger is in charge of heat treating and inspection.

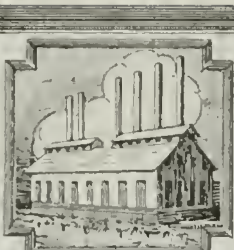
A. M. BYERS COMPANY MAKES IMPROVEMENTS

A self-supporting stack to take care of the hot blast stoves has been built for the blast furnace at Girard, Ohio, of the A. M. Byers Company, Pittsburgh. At the bottom the stack is 14 ft. inside diameter, tapering in 45 ft. to 8 ft. ¾ in. in diameter and continuing at this diameter for 180 ft., or a total height of 225 ft. It is provided with a coping ring on top for keeping the moisture off the brick lining, also with a ladder and safety cage of such construction that the workman climbs between the ladder and the stack. In other words, there is a bar frame work extending from the ladder to the stack, creating a cage; ordinarily, there is a space between the ladder and the stack, and the safety cage is on the outside of the ladder.

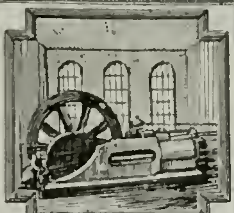
The 16 foundation bolts are 3 in. in diameter, and they extend through a U-shaped bracket forged from one solid piece of ⅝-in. plate. These brackets are 4 ft. high. The stack was built by the Sharpsville Boiler Works Company, Sharpsville, Pa.

CONVENTION ANNOUNCED

The twenty-fifth annual meeting of the American Society for Testing Materials will be held on June 26-July 1, 1922, at Atlantic City, N. J., with headquarters at Chalfonte-Heddon Hall Hotel.



STEAM POWER DEPARTMENT



Steel Works Power Plant Management

Permanent Statistics for the Power Plant—Pocket Note Book Records Should Be Destroyed and Statistics Kept in a Permanent Way.

By ROBERT JUNE, Mechanical Engineer

COMPLETE permanent specifications of equipment, properly filed, are not found in as many modern power plants as they should be. This is due rather to some neglect or lack of knowledge of how to proceed to keep these statistics in good shape rather than to lack of appreciation of their importance. It is indeed unusual to find the plant in which the operating engineers do not have some statistics written down in their pocket note books. Every one will agree that the pocket note book is not the place for this data. It should be kept in a formal manner and the records should be available at all times regardless of changing plant personnel.

The keeping of accurate specifications of equipment installed, greatly facilitates the making of repairs. It is of great value when the new engineer comes on the job, and it has a very important function in the adjustment of fire losses, should such occur.

The presentation of specifications of equipment not only serves as an accurate inventory of the contents of the plant but strengthens the case for the owner and is particularly valuable when the owner has gone to considerable expense to maintain old equipment lost in a fire. Moreover, in the event of a fire, such of the old equipment as it is desirable to replace, can be ordered without an instant's loss of time. The completeness of the specifications should increase with the value of the investment in the plant.

Power Plant Building.

Figure I indicates the desired specification data on the power plant building. This form is, of course, subject to some modifications, depending on the individual structure. However, all of the information contained in this form should be filed in ordinary cases, and if the building is large, additional information will suggest itself.

This information is, of course, of great value in connection with the plan of new buildings and additions, and is also of value to the accounting department in setting up depreciation reserves.

As an illustration of the value of these records, let us suppose that we want to construct an additional building. The specification data tells us where we can match the cut stone or terra cotta trim of the original building. If new equipment is to be installed, we can tell by immediate reference to this sheet what the permissible floor load is. If any of the materials of construction, such as roofing, becomes defective, we can readily tell who the manufacturers were and ascertain at once whether a guarantee has been made to cover the life of this particular part. If we get unusually good service out of flooring, painting or roofing, and wish to use the same specifications in another building, we can get the data from this sheet.

Figure I.

POWER PLANT BUILDING DATA.

Dimensions—
Length............ Width............ Height..........

Type of construction—
Steel, concrete, wood, combination......................
Name of general contractor..............................
Name of excavating contractor...........................
Foundation down to elev.................................
Kind of soil with permissable load......................

Floor loads permissable—
Engine room.................. Basement................
Boiler room...
Masonry contractors ....

Cu. yd. of concrete and proportion used—
Foundation ....Yd. prop.....................
Walls..................... Floors.....................

Structural Steel fabricated by..........................
Lb. of steel—Reinforcing...........Structural.............
Common brick.....................M.
Face brick.........M. Manufactured by....................
Enameled brick........M. Manufactured by...............
Cut stone........cu. ft. Manufactured by..................
from....................Quarry.
Sash—Wood..................... Steel.....................
Manufactured by...
Terra cotta cu. ft................Type of roof..............
Guarantee................ Manufactured by...................
Ventilators............ Manufactured by....................
Lighting type........... Manufactured by...................

Plumbing and heating........ Installed by..................
Glazing.............. Installed by.........................
Painting............ Installed by..........................
Floor preservative......... Done by........................
Guarantee............ Manufactured by.....................
Completed .... Total cost....................

Boiler Data.

The boiler room is often the heart of the entire plant. If something goes wrong with the boiler, it affects progress in all departments. We need to have complete information regarding the boilers available at all times. True, we usually have blueprints, or ought to have them. The actual installation, in some instances, may vary from the blueprints, but there is a certain amount of information regarding the boilers to be obtained from the specifications furnished by the manufacturers. It is possible to put all this information in one place and on a single sheet, Fig. II.

Figure II.

BOILER DATA.

Plant No........Builders No........
Location ....

Manufactured by..
Factory address..
Nearest office address...................................
Man to call regarding repairs............................
Phone.................... Date installed..................
By whom ....
Type.......... Weight boiler.......... Weight water.......
Tubes, No............ Diameter.......... Length..........
Made of................ Steam pressure gauge..............
Safety valve—
Pressure........ Type...... Diameter...... Number.......
Steam space, sq. ft.............. Water space, cu. ft...........
Heating surface, sq. ft....... Superheating surface, sq. ft......
Area of grate........... Type of grate or stoker...........
Rated horsepower ....
Ratio of heating surface to grate area...................
No. of steam drums......... Dia. of steam drums, in.........
Thickness of shell, in........ Thickness of head, in..........
Type of joints........... Dia. of steam nozzle in............
Dia. of blowoff, in.............. Dia. of feed pipe, in...........
Temperature of feed water............ Type draft...........
Maximum draft............... Height of setting............
Length of setting.................Thickness of walls..........
No. of fire brick............ No. of common brick...........
Distance between batteries...............................
Distance from back of boiler to wall.....................
Distance from front of boiler to wall....................
Manufacturer's guarantee ....
Combined boiler efficiency—
100% rating....... 200% rating....... 300% rating.......

Economizer Data.

If economizers are installed in connection with our boilers, we want the data concerning them to be as readily available as that of the boilers. If economizers are equipped with scrapers, there is frequent need to make replacements, and we also want the manufacturers to guarantee this equipment for us so that we can check up the performance of the equipment. Figure III gives this essential information.

Figure III.

ECONOMIZER DATA

Plant No........ Builders No.......
Location ....

Manufactured by..
Factory address..
Nearest office address...................................
Man to call regarding repairs............................
Phone.................. Date installed...................
By whom ....
Type........ Weight economizer....... Weight water......
Tubes, No...... Diameter...... Length...... Made of......
Heating surface per sq. ft. boiler heating surface, sq. ft........
Heating surface per boiler horsepower (34.5 lb. water per hr.) rated capacity, sq. ft...............
Cleaning: If by scrapers.
Type motor...... H. P...... A.C or D.C.......Voltage....
R.P.M............. Make motor..........................
From whom purchased..................................
Name and address to call regarding repairs...............
....
Cleaning: If by mechanical soot blowers.
Make of soot blower................... Type............
No. of units........ Size riser pipe...... Size header......
Make and size of valves..................................
Name and address to call regarding repairs.............
Manufacturer's guarantee:
Feed water lbs. per hr..................... Temperature leaving economizer when entering at 180 deg. F...........
Gas temperature entering deg. F........................
Gas temperature leaving deg. F.........................
Gas temperature difference.............................

Soot Blower Data.

The economical soot blower insures high boiler efficiency and they save fuel. They are an essential part of our equipment and it is extremely important that we should keep the blowers in the best operating conditions at all times. A sheet made out in accordance with Figure IV gives us all of the essential data on this important piece of equipment.

Figure IV.

SOOT BLOWER DATA.

Boiler No. ....
Location ....

Manufactured by..
Factory address..
Nearest office address...................................
Man to call regarding repairs............................
Phone................... Date installed...................
By whom..
Type..................... Trade name.....................
Number of calorized units................................
Number of plain units....................................
Diameter of header.......................................
Diameter of risers.......................................
Diameter of drains.......................................
Location of units (see blue prints)......................
Diameter of nozzles......................................
Type of nozzles..
Make of main valve.......................................
Make of individual valves................................

Condenser Data.

In Figure V we have a typical figure to keep our condenser statistics. Here we have all the necessary data on length, diameter, and thickness of tubes, data on circulating, dry vacuum and hot well pumps, capacity of the condenser, etc. This information is of great value to the operating force.

Figure V.

CONDENSER DATA.

Plant No........ Building No.......
Location ....

Manufactured by..
Factory address..
Nearest office address..................................
Man to call regarding repairs..........................
Phone.................. Date installed....................
By whom...
Type...................... Weight condenser..............
Weight water.................. Tubes, No...............O.
Diameter.......... Thickness............ Length..........
Made of............................ Cap. lb. steam per hr.
at............in. vac. and cooling water at...........deg. F.
Steam condensed per sq. ft. of surface, lb...................
Total tube surface per condenser, sq. ft......................
Manufacturer's guarantee:—With............gal. 70 deg ctr.
water, vacuum in condenser................in..............
Hot well temperature....................Cross sectional area
intake tunnel........sq. ft........Discharge tunnel....sq. ft.
Circulating pumps:—Type..................................
Manufactured by..
Address ....
Size.............. Capacity, gal. per minute................
Circ. water pumping cap. per lb. of steam condensed at consumption of........lbs. Per Kw. Hr. Lbs..................
Cooling water per lb. of steam at full load, lb................
Screens at circulating water intake, type....................
Dry Vacuum Pump:—Type.................................
Manufactured by..
Address ....
Size.................. Capacity...........................
Hot Well Pump:—Type....................................
Manufactured by..
Address...
Size............. Capacity gal. per minute.................
Remarks ....

Feed Pump Data.

In filling out our feed pump statistical data sheet, Figure VI, we should tell whether the feed pumps are centrifugal, reciprocating or rotary, and should give the diameters and sizes of the main parts. In connection not only with the feed pump data but with the data of other types of equipment, it would be well to maintain a file of catalogues, and particularly of spare parts catalogues.

Figure VI.

FEED PUMP DATA.

Plant No........ Building No.......
Location ....

Manufactured by..
Factory address..
Man to call regarding repairs..........................
Phone.................... Date installed..................
By whom...
Type.............. Weight.............. Stroke............
Diameter of steam cylinder..............................
Diameter of water cylinder..............................
Displacement per stroke, cu. ft.........................
Number of strokes per minute, average....................
Steam pressure, per lb........ Back pressure, per lb........
Number of valves.............. Type of valves.............
Pounds of water per 24-hr. average, actual..................
Dia. of suction........... Dia. of steam discharge...........
Dia. of steam pipe............... Dia. of exhaust............
Dia. of steam drips.......................................
Piston Packing.................... Size....................
Rod Packing..................... Size....................
Temperature of feed water deg. F.........................
Suction head, lb. per sq. in..............................
Discharge head, lb. per sq. in............................

Remarks: ....
....

Chimney Data.

As the chimney is not a complicated proposition, we do not need to record as much information regarding it, but there are a number of points which should be noted and filed. These are covered in Figure VII.

Figure VII.

CHIMNEY DATA.

Plant No........ Building No.......
Location ....

Manufactured by..
Factory address..
Man to call regarding repairs..........................
Phone.................... Date installed..................
By whom...
Type....................... Weight...................tons
Construction material data...............................
....
....
No. of boilers served.....................................
Stack area per 1,000 sq. ft. of boiler heating surface......sq. ft.
Height above grate, ft............Size at breeching..........
Diameter at top...
Amounts of material used.................................
Common bricks, No. of..................................M.
Fire bricks, No. of.....................................M.
Yards of concrete............ Reinforcing steel...........
Sheet steel..
Remarks: ....
....

Turbine Data.

Turbine data covers the capacity, operating conditions, performance guarantees, etc. It is a very good thing to have this information constantly before the operating men as they are much keener to check up results with actual records. (Figure VIII.)

Figure VIII.

TURBINE DATA.

Plant No........ Building No.......
Location ....

Manufactured by..
Factory address..
Man to call regarding repairs..........................
Phone.................. Date installed....................
By whom...
Type.............. Weight............. R.P.M............
Heaviest piece to be lifted by crane...................tons
Operating pressure........Operating superheat, deg. F.......
Exciters, No............. Capacity each, Kw..............
Types............ Manufactured by.........................
Main unit cap. per kw. cap. of exciters installed, kw..........
Performance guarantee—Operating condition:
Lb. press. abs................Deg. F. superheat............
In. vac. condenser............. In. barometer..............
Net kw. load of generator..................................
Lb. of steam per kw. hr....................................
For different pressures and deg. above or below normal temperatures following factors to be used................% for each 15 lb. press. for range of 25 lb. above or below normal.
Blade data...
....
Remarks: ....
....

Method of Filing.

The forms outlined herein should properly be made out in duplicate, one copy on file in the superintendent's office, or in the main office, and one in the power plant. They can well be made out on type written sheets, placed in loose leaf record books. The forms given cover the principal equipment. Forms will suggest themselves for the minor items of equipment and these can be made out, using the forms given herein as a guide.

If an engineer has before him complete information of all details of the equipment which he is handling, he is encouraged to keep close watch over performances. The forms can be very easily made to suit the particular conditions of any given plant and they can very easily be filled out.

Firing Boilers With Fuel Oil

Indications Point to the Fact That Fuel Oil Will Be Used to a Greater Extent Than Ever Before in the Firing of Boilers—Oil Market One of Advantage at Present.

EVERY fuel has some particular field in which its use predominates. In practically every case the reason for this is to be found in low cost. Again, low cost prevails because of advantageous freight rates. Exceptions exist where some particular process requires some other fuel more suitable physically or chemically. Again, competition may arise, due to fluctuations in demand for some one of our several fuels. There is probably no better illustration of the truth of the above statements than is accorded by the fuel oil market during recent years.

On the Pacific coast and to a lesser degree on the Atlantic, petroleum enjoys wide popularity due to the fact that it can be purchased at a comparatively low figure. The oil fields of California afford a supply for the western coast, while the Mexican and Gulf fields are made accessible by water shipment to the eastern coast.

During the war the demand for fuel oil for ships increased tremendously due to apparent advantages this fuel possesses as a war-time fuel for vessels. For this reason the demands on land were made subservient to those on sea. During this period it was almost impossible to obtain a contract for oil. Today conditions are the reverse, with strong indications of a decided slackening in demand for oil for seagoing vessels. The scrapping of so many warships with a ten years' vacation in construction will be a further impetus towards lessening the demand.

With prospects of an increased supply of petroleum for use on land, greater interest will naturally be aroused in this fuel, especially for heating boilers. Aside from boilers, the greatest demand is from metallurgical furnaces, the majority of which are of small size and in which other fuels are not economical due to physical characteristics.

Fuel oil possesses the following advantages:

1—Economy of space. One cubic foot of oil at 26 Baume weighs 55.9 pounds and will contain about 19,000 Btu. per pound.

2—Can be readily handled due to it being a liquid.

3—Requires a small crew to handle boilers and furnaces.

4—Elimination of ashes.

The above are the principal advantageous features. It will be observed that the advantages noted above are those which apply not only to vessels, but also to plants, such as office buildings, where there is restricted space and where ground is valuable. Fuel oil, therefore, has a special field in plants located in large cities or in places where there is little room for equipment. Where such limitations do not exist, the advantages of oil are less apparent, unless the cost is greatly in its favor.

In addition to the four features named above, there are others of minor importance and which are not exclusive to oil. Powdered coal, for instance, as well as oil, possesses these advantages:

1—Elimination of smoke. This is particularly desirable in a city where the restrictions on smoke are strictly enforced. Cooler boiler room.

2—Saving in labor.
3—High furnace efficiency.
4—Control of fire simplified.

The actual firing of boilers with fuel oil presents some very interesting problems which are at times difficult to solve. These have to do generally with the control of the air and design of the furnace. In many cases plants which have burned coal on grates are changed so that oil can be substituted. In two plants recently visited, one formerly burned anthracite coal while another had been stoker fired. Oil firing and coal firing are entirely different and in each of the plants mentioned they had considerable difficulty obtaining smooth working conditions.

Comparison between oil and coal can all be reduced to two factors—comparative cost and plant location. For boilers, in most localities, coal is the cheaper, but in some districts oil competes with coal at certain times. In such districts the boilers are equipped so that oil or coal can be burned depending on which presents the greater advantage on a cost basis. The price of oil has been so uncertain in recent years that most plants are compelled to equip their boilers so that they can change to another fuel quickly. A large equipment company has placed stokers on their boilers and oil burners in the rear. This plant can change from oil to coal in one hours' time. What advantages oil possesses over coal outside of cost lie in the fact that it is a liquid and has a high heat value per pound. The actual performance of a boiler burning oil, day by day, can be rated as little if any better than coal.

The information which follows has been gathered from representative plants which have been burning oil under their boilers for some years. Two types of burners were investigated. These were both of the type known as "outside mixing." The atomizing agent was steam.

The choice of burner will depend on conditions obtaining at the plant in question.

Where boiler feed water is of vital importance as on vessels, the high pressure mechanical burner is to be preferred as no steam is used for atomizing and none lost up the stack. These burners require an oil of low viscosity. Heavy Mexican oil for use in a mechanical burner should be heated to 250 deg. F. or higher. The pressure at the burner will be on an average of about 200 pounds. To secure this temperature and pressure of oil, steam must be used, but it will be returned to the condenser and hence is not lost. This steam will amount to approximately 2 per cent to 3 per cent of the total feed water fed to the boilers. This percentage will, of course, vary, depending on the particular conditions at the plant. Where such high pressures are maintained the piping must be such as to leave no question of security. This is further enhanced by installing an automatic stop valve which automatically shuts off the oil supply, should a break in the line occur.

On land, the majority of burners are those which atomize the oil by steam. Representative burners of this type are the Hammel and Best. The steam should be dry and at a boiler pressure of 100 pounds or higher. The oil burned under a 500-hp. boiler in a large office building was heated to 146 deg. and was at a pressure of 40 pounds. This was Mexican oil. Lighter oils obtained in the United States need not be heated if they are at about 26 Baume.

The oil should be atomized to an exceedingly fine mist in order that it may be gasified readily. All that any of the so-called burners can do is to break the oil up and discharge it into the furnace so that it can easily be gasified. The oil will be gasified by heat and it is this gas which must be mixed with air. Unless this is the case combustion will not be efficient. This point may be brought out more clearly by considering the composition of oil and the manner in which it burns. All oils are composed of liquid hydrocarbons whose exact chemical structure is not readily determined. The burner—or more correctly the atomizer—breaks up the liquid only. The fine liquid mist is gasified by heat and the hydrocarbons broken up into their elements—hydrogen and carbon. The hydrogen and carbon burn to water and carbon dioxide if combustion is complete. If not complete there would be free hydrogen and carbon or carbon monoxide. It is the hydrogen and carbon then which must find their necessary quota of oxygen, which of course comes from the air. The air then must be thoroughly mixed with the gaseous hydrocarbons as they break up into their constituents. It is not enough that the air and liquid hydrocarbons be mixed, but the further step as outlined must be accomplished. The lack of such a condition produces carbon as soot. This is not the only manner in which soot may be produced, but it is one of them.

Many different furnace designs have been tried out with the intention of securing correct combustion. In one of the furnaces in a large steel plant the floor of the furnace is perforated and air is drawn in through these perforations. In another boiler plant the air is induced by the burner, aided by the draft created by the stack. The floor here is solid and all air enters around the burner.

A feature of great concern is the regulation of the air in proper proportion to the oil. This is done by appropriate mechanism or by hand. It requires far less draft for a boiler burning oil than for one burning coal. In the oil fuel furnace there is no fuel bed through which the air must be drawn. Therefore in a plant where oil is substituted for coal there will be a tendency to carry too strong a draft unless precautions are taken to check up the excess air. A smoky flame will indicate an insufficient air supply, but excess air is not apparent to the eye. In the office building previously mentioned, the CO_2 varied from 13 per cent to 15 per cent. The draft over the burners was .1 inch. Where the CO_2 is carried too high there is a chance that CO may be present in the gases and instead of a high efficiency it may actually be lowered.

The flame in the boiler should be so controlled that combustion will be complete before it strikes the cold tubes. Otherwise the carbon will not be burned, but will appear on the tubes as soot. This can be cleaned off with a lance or by soot blowers. The direction of the flame on leaving the burners should be such that there is no contact with the floor of the combustion chamber nor with the tubes.

Tests made show that efficiencies of from 75 per cent to 82 per cent can be obtained, but over a long period efficiencies of 80 per cent to 82 per cent are not common. In a series of tests made recently, the lowest was 76 per cent, while the highest was 83 per cent. The boilers were 500-hp. Babcock & Wilcox. The capacity ran from normal to 181 per cent.

The amount of water evaporated per pound of oil will average from 12 to 14 pounds. The highest evaporation on the test was 15.85 pounds, at which rate the evaporation from and at 212 deg. per square foot of heating surface was 3.90 pounds. The highest evaporation per square foot of heating surface was 5.75 pounds.

In electric lighting plants comparison is usually made from day to day in terms of kilowatt hours per barrel of oil. Running with a light load, 122 kw. hours were obtained in daily operation. With a heavy load, this figure would be materially bettered. Two hundred kw. hours have been secured per barrel of oil.

As is the case in all plants where fuel of any kind is burned, the really important factor is the personnel. Expressed in plainer terms, the supervision of the actual burning of the oil determines the results. In this connection the results achieved have not always been what they should be due to the fact that the operators did not understand the proper handling of the oil burning equipment. The phenomena attending the combustion of oil are not as apparent to the eye as is the case with coal. For this reason all boiler plants burning oil should be equipped with a full set of instruments as only by these instruments can the attendant check his observations. In starting a plant, expert supervision will be required until the attendants have had time to thoroughly familiarize themselves with the equipment.

The answer to any problem such as that discussed will be found in the cost sheet. Therefore, all factors having any bearing on the relative merits of oil and coal should be fully investigated.

The supply of coal is practically assured while, judging from past experience, there is not the same assurance in regard to oil.

Development of Rolling Mill Engines

The Gas Engine Is Not a Good Type of Engine for Rolling Mill Work—However, the Combination of a Gas Engine with a Steam Engine Has a Decided Advantage.

By F. J. DENK.

THE development of the rolling mill engine has followed the same course, as that of the other steam engines. Starting out with the single cylinder engine, the way led to the compound engine and, for flywheel drives, to the triple expansion engine. The reason for this development was, that the steam consumption had to be kept, for economical reasons, as low as possible, and single cylinder engines could, at the early times, not be classed among the economical steam users. With the introduction of the compound engine, naturally, the disadvantages, adherent to this type of steam motors, had to be taken into account. In the first place, the construction and design of a compound engine is more complicated and, therefore, more expensive, than that of a single engine. Cost for repairs and maintenance is much higher. The high pressure cylinder of a compound engine works, at normal load, with a higher cut-off, than that of a single cylinder engine, and the danger arises, that, at sudden large increases of the load, the multiple compound engine cannot overcome the peak and will stop dead. Another disadvantage, connected with the operation of a compound engine, is due to the fact, that, as soon as the ingots enter the rolls, the high pressure cylinder has to take care of the full load, whereas the work done by the low pressure cylinder lags behind. Only after a number of revolutions have passed, the receiver pressure will be big enough to make the low pressure cylinder take up the larger part of the work, which it should always do. But, for the first few passes, the time, during which the ingot will be between the rolls, will be so short, that the ingot will have left the rolls, before the low pressure cylinder had time, to take up its share of the work, and, in this respect, the compound engine is not as good as the single cylinder engine, where every increase in the load is taken care of by a corresponding increase of the work done by the engine. This was one of the reasons why single cylinder engines have held their position in the rolling mill industry, because simplicity in construction, economy in steam and oil consumption and perfect adaptability to prevailing load conditions are points, which cannot and should not be overlooked.

The following table shows the steam consumption and the percentage of work developed, used for rolling, for different types of mill engines. For comparison's sake data for an electrical drive are also given.

Type.	Lbs. Steam/I HP-hr.	% of Work Consumed in Rolling.
Three-high,	22	82
Twin tandem compound, condensing, geared,	35	80
Twin single cylinder, non-condensing, geared,	45	75
Twin tandem, compound, condensing,	35	65
Twin tandem compound, non-condensing,	50	57
Electric,	..	74

The data are taken from average American and European practice and show, in a general way, the performance of the different types of rolling mill drives. A decided difference in the percentage of the work consumed for rolling can be noticed. The reciprocating engines, of course, are at the top of the row with a useful work of 82 per cent, because the flywheel engine does not have any losses for accelerating the revolving masses. The twin tandem compound drives show a wide range in the percentage of useful work, viz.: 80 per cent, 65 per cent and 57 per cent. The first figure comes from a geared engine with a gear ratio of 1:2.5. This alone is enough to account for the large percentage, as the reduction in power required is proportional to the square of that gear ratio, or, in the present case to 1:6.25. Besides, this engine is a European design, which, as a rule, are built lighter than our American engines.

The table shows furthermore, that the single cylinder engine has a higher percentage of useful work, than the twin tandem compound engines, mentioned above. The engine in question is geared, but the gear ratio is so near unity (about 1:1¼), that most of the difference must be ascribed to the reasons given above as adhering to the construction design and operation of the compound engines.

The electrical drive does 74 per cent of useful work, the rest is consumed in acceleration losses (9 per cent), friction losses (11.5 per cent) and copper losses (2.5 per cent).

European practice (*) has turned to some new types for driving rolling mills, although it must be said, that American engine manufacturers have directed their attention in the same direction, at least to a certain extent.

The single cylinder steam engine has been developed as a uni-flow engine with a short piston and with the exhaust ports in the middle of the cylinder. The compression in this type of engine amounts to about 60 per cent; it is, therefore, still comparatively high. During expansion the exhaust ports are kept closed by means of a valve located behind them. About 10 per cent before the dead point, the valve opens and the steam is exhausted. The arrangement as described is a disadvantage connected with this type of uni-flow engines, as far as rolling mill work is concerned, because here it is imperative, that, when working with large cut-offs, the large quantities of steam must have a chance to escape unthrottled, thus equalizing completely the pressure in the cylinder and in the condenser.

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*Stahl und Eisen, Vol. 41, No. 46, p. 1649 FF.

Several other types of uni-flow engines have been developed, which are improvements over the designs of the older types, whereby it was kept in mind, that one of the most important parts of a single cylinder rolling mill engine is the arrangement and the working of the exhaust valves, in order to enable them to discharge easily and effectively the large quantities of steam which are required by the engine whenever sudden peak loads occur.

Steam economy can also be effected by a well and efficiently working condenser. A vacuum of 3 to 4 in. Hg is very good, but it will hardly be obtained in regular practice; 8 to 10 in. Hg can easily be reached, but in most cases the vacuum will stay below this figure.

In order to obtain the highest possible economy with a non-condensing engine, the exhaust steam should be used for heating and similar purposes. In case this cannot be done, the best uni-flow engine will suffer under the same disadvantage, adherent to every steam engine of the non-condensing type, that is, its very low thermal efficiency.

This has been one of the reasons, why it has been tried to replace the steam engine by the gas engine; it has also caused a big advance in the application of electrical drives, the motors of which are supplied with current from a central station which can, in the case in question, work with a higher efficiency than a steam plant.

The internal combustion engine is far superior to the steam engine in blast furnace and coke oven plants, where the power gas is at hand and would otherwise be wasted either entirely or to a large extent. But as a rolling mill drive a gas engine is inferior to the steam engine, because it can only carry a very small percentage of overload, thus forcing the mill superintendent to install units which are by far larger than his ordinary power requirements demand. The gas engine must, therefore, be designed for a capacity from 50 to 80 per cent higher than necessary, and this, in turn, is followed by the further disadvantage, that the heat consumption increases, when the load decreases, thus reducing the superiority of the gas engine over the steam engine considerably, as far as thermal efficiency is concerned.

The operation of the gas engine is also not without fault, because ignition may set out, and if this happens several times in succession at full load, the engine will stop. For all these reasons, the gas engine has not made very much headway as a rolling mill drive. But it can be shown, how a combination of a steam engine with a gas engine, forming one driving unit, may be used to advantage.

In such a case, the gas engine will have to take care of the regular average load, whereas the steam engine has to overcome the peak loads. Needless to say, that the load variations, which the steam engine will have to take care of, are greater in this case, than with the pure steam drive. The steam engine must, therefore, be designed in such a way, that it is capable to take care of all these variations with the highest possible thermal efficiency. This condition is best filled by the uni-flow type of steam engines. Tests made under the same working conditions have shown, that a uni-flow engine has 12 per cent efficiency, the gas engine 14 per cent and the combined steam-gas unit 17 per cent. The saving in fuel of the gas engine over the steam engine amounted to 14 per cent, and that of the combined steam-gas unit over the steam engine to 29 per cent.

The design of the steam-gas unit can be made in such a way that the steam cylinder is in front and the two 4-cycle gas cylinders in the back, all in the same axis and all three working on the same crank. Simpler, however, is the arrangement as a twin engine, one side being formed by the gas engine and the other by the uni-flow engine. The most compact design is represented by a horizontal-vertical outfit, the steam engine being the vertical part, located in the axis of the horizontal gas engine and both working on the same crank pin. The two last named designs have the advantage, that the gas engine can be cut out entirely, if necessary.

Conclusion.

The percentage of useful work done in rolling is shown for different types of steam driven rolling mill engines. It is furthermore shown, that a gas engine is not a good type of engine for rolling mill work, but that the combination of a gas engine with a steam engine will have decided advantages over either one of the pure drives. Different arrangements of such a combined steam-gas unit are described.

THE STUDY OF MOLYBDENUM ORES

The United States possesses the largest known deposits of molybdenum ores, but is relatively poor in high-grade deposits of some other important alloying elements used in alloy structural steels, such as automobile steels, says the Federal Bureau of Mines Nickel, chromium and vanadium are the standbys in present-day alloy steels. Of these we have very little nickel, some chromium, mostly in relatively low grade ores, and only small deposits of vanadium. It is of utmost importance to know to what extent molybdenum can replace any of these elements. Moreover, there is as yet comparatively little market for molybdenum.

According to tests made by H. C. Chandler and C. H. Willis, given wide publicity by producers of molybdenum, that element as an alloying material ranks with nickel, chromium and vanadium in preparing steel of high quality. Molybdenum steels found some use during the war, but their production thereafter almost ceased.

In order to corroborate the published tests, to extend them, and to study in detail the shock and fatigue-resisting properties of molybdenum steels, a co-operative agreement was entered into by the Bureau of Mines with the Vanadium Corporation of America, producers of molybdenum, by which the services of R. J. Thompson, metallographist, were made available. The co-operation of the Wyman-Gordon Company, Worcester, Mass., was enlisted in making impact and repeated-impact tests.

A comprehensive series of molybdenum steels and of other steels for comparison has been made in the electric-furnace laboratory of the department of chemistry at Cornell Universty and rolled at the Halcomb Steel Company plant and test bars were machined, heat treated, and given tensile and fatigue tests in the shops and laboratories of the Sibley School of Mechanical Engineering at Cornell University.

NEWS OF THE PLANTS

The Slatington Iron & Steel Company, Slatington, Pa., recently incorporated with a capital of $105,000,000, under Delaware laws, is arranging details for the construction of a new steel manufacturing plant in the vicinity of Birmingham, Ala., on site recently acquired. Notice has been filed with the state of organization and intention to build. The initial unit is estimated to cost in excess of $500,000, and will comprise a number of mills. The company will also construct a blast furnace at a later date. Iron and coal properties have been acquired in Etowah County, Ala., consisting of about 10.000 acres of land, and these will be developed. A complete iron ore plant will be installed on the site. John W. Baker, 711 Lumber Exchange Building, Chicago, Ill., is one of the principals of the company.

The Lafollette Coal & Iron Company, Lafollette, Tenn., has preliminary plans in progress for the construction of a by-products coke plant, to be used for the carbonizing of fuel and other service at the local mills. The plant will have a monthly output of about 13,000 tons. It is estimated to cost about $500,000, including machinery and equipment. Parker & Wilder, Cincinnati, Ohio, are engineers for the company in charge of the project.

The Lorain Steel Company, Johnstown, Pa., has construction under way on a new electric steel foundry at its local works, and plans to place the plant in operation at an early date. A 4-ton electric furnace will be installed.

The Wickwire-Spencer Steel Company, Buffalo, N. Y., has increased operations at its local finishing mill to full capacity under regular working hour schedule.

The Duluth-Globe Iron Works, First and Hughitt avenues, Superior, Wis., has plans under way for the construction of a one-story addition to its plant at Duluth, Minn. It will be 125x130 feet, located on Michigan street.

The Hudson City Steel Company, 233 Broadway, New York, N. Y., has preliminary plans under consideration for the construction of a new steel plant at Hudson, N. Y., to consist of a group of buildings. It is proposed to commence construction early in the spring. Dwight P. Robinson & Company, 125 East Forty-sixth street, New York, are engineers.

The Slatington Iron & Steel Company, Slatington, Pa., is making a number of improvements at its plant, including repairs to machinery, and plans to resume operations at an early date. The works have been closed down for a number of months past. Robert Grant, Woodworth Building, New York, heads the company.

The Bethlehem Steel Corporation, Bethlehem, Pa., has improvement work under way at its works at Lebanon, Pa., including the construction of an addition to the concentrating and sintering plant, and improvements in the galvanizing department. Extensions will also be made in the pickling department as well as in the wire-treating shop. The company is also constructing an addition to the 28-inch billet mill at its main works at Bethlehem.

The Builders' Iron & Steel Company, Bridge street, Cambridge, Mass., has awarded a contract for the construction of a new plant on Garvey street, Everett. Mass., to comprise a modern iron and steel works. It will be 70x250 feet, and additional units, it is understood, will be erected at a later date. The initial plant will cost approximately $75,000. Howard P. Farmer is president of the company. Blake & Pope, 15 Beacon street, Boston, Mass., are building contractors.

The Charcoal Iron Company, Detroit, Mich., is making a number of improvements at its iron ore works in the Manistique, Mich., district. The plant will be placed in operation immediately. The company has increased production at its iron ore properties at Bessemer, Mich., and a day and night shift are working under regular schedule.

The Richmond Car Works, Richmond, Va., recently organized under state laws with a capital of $500,000, has acquired the government plant at South Richmond, originally designed for a marine boiler works, but never occupied. The plant covers a large tract of land and consists of a number of buildings. It will be equipped and used by the new company for the manufacture of architectural steel and iron products and affiliated specialties, as well as railway and other cars. The main building is 180x600 feet. The plant was acquired for a consideration in excess of $200,000. Lewis C. Williams is president.

The Bethlehem Shipbuilding Corporation, San Francisco, Cal., a subsidiary of the Bethlehem Steel Corporation, Bethlehem, Pa., has acquired the plant of the Southwestern Shipbuilding Company at Los Angeles, Cal., and will convert a portion of the plant into a steel fabricating works for the manufacture of structural shapes for building and other service.

The Wheeling Steel Corporation, Wheeling, W. Va., has plans in progress for the construction of a number of additions to its LaBelle Iron Works plant, Steubenville, Ohio. The work will consist of a new reversing blooming mill, to be provided with heavy shears, tables, transfers and affiliated equipment. Other work is also contemplated.

The American Steel & Wire Company, Worcester, Mass., a subsidiary of the United States Steel Corporation, New York, is perfecting plans for the construction of the proposed additions to its plant for increased production. The first structure to be erected, and plans for which have been completed, will be 60x900 feet, located at the North Works, and will be used primarily for galvanizing operations. Extensive electrically-operated equipment will be installed. The plant will cost about $50,000. The Engineering Department at the works, under the direction of Charles E. Goodrich, chief engineer, has plans in progress for other additions to be made at the plant, estimated to cost about $275,000. Work will be placed under way at an early date.

The Chicago Bridge & Iron Works, Chicago, Ill., is increasing production at its steel fabricating plant at Greenville, Pa., and a night shift has been added to the working force.

The Mansfield Sheet & Tin Plate Company, Mansfield, Ohio, is proceeding with construction work on a number of plant additions, and proposes to have the units ready for service at an early date. The expansion will comprise four 80-ton open hearth furnaces, with new blooming mill and sheet bar mill, the latter to be equipped to handle material, 24-inch.

PRODUCTION TOPICS

The work of the Bureau of Mines on iron ores is directed chiefly toward devising means for utilizing extensive deposits of low grade ores that cannot be smelted profitably by present methods. In order to utilize such ores, it is necessary that enough of the gangue and impurities be removed to raise the ore to smelting grade, or methods of smelting ore of lower iron content must be devised.

The North Central mining experiment station of the Bureau of Mines, at Minneapolis, Minn., has continued to co-operate with the state mining experiment station in an investigation of the reserves of low-grade ore in the Lake Superior district, and in milling tests of samples collected in the course of the field work. This work has also included experimental tests of low-grade iron ores in the southern districts. With the establishment of the mining experiment station at Birmingham, Ala., more extensive work has been made possible, and a comprehensive survey of the iron and steel industry of the Birmingham district has begun. The main object sought is to develop means of beneficiating the low-grade highly silicious ores that occur in large quantities in that district. At Minneapolis, the work has been more closely related to utilizing low-grade manganiferous iron ores of the Lake Superior district, particularly as regards the study of blast furnace practice, and the operation of the experimental blast furnace at that station.

The investigation of the heat treatment of drill steels has been continued by the Bureau of Mines, and the scope of the work greatly extended. The breakage of drill bits in use constitutes an important part of mining costs, and the object of this work is to determine the causes of breakage and to find means for their elimination.

The Mississippi Valley experiment station, which has its headquarters for field work at St. Louis, Mo., and its laboratories at Rolla, Mo., is co-operating with the Minneapolis station in the investigations of drill steels.

In the course of the rock-drilling and drill-steel investigation in the Tri-State district, work has been started to find out the most efficient change of gauge to use between different lengths of steel. Present practice favors changes of from one-fourth to three-sixteenths of an inch, but it is planned to try changes as small as one-sixteenth inch. A reduction in gauge means decreased drilling cost, as the work of drilling varies with the size of the hole. It is also planned to try out smaller sizes of drill steel. The size of drill steel now in use in this district is 1¼-inch round. In several other districts where the large size was formerly used the same work is being done with smaller steel, thus reducing the cost of the steel, lessening the work of the miner in transporting steel, and increasing the drilling speed. Steels 1 inch in diameter will be tried and results will be compared with tests with the larger steel. The results thus far indicate that the 1-inch steel can be used successfully and that a considerable saving in drilling cost will be effected.

The experimental blast furnace built at the Minneapolis station by P. H. Royster, assistant metallurgist, and T. L. Joseph, assistant metallurgist, was put in blast 12 times for the study of blast furnace reactions as related to low-grade manganese ore now available in the United States. Fundamental data were collected and used as a basis for future experiments. Experiments have been conducted on the flow of gases and the flow of stock in blast furnaces. Other subjects of investigation have included the following: Volatilization of manganese in the blast furnace; history of blast furnace lines, shapes, and sizes; the rate of reduction of iron oxide by carbon monoxide gas; the production of high-silicon pig; charcoal iron furnace practice.

The Bureau of Mines station at Seattle has been engaged in making a general survey of the iron and steel situation in the Pacific coast states, with regard to consumption of iron and steel and the supply of raw materials for their manufacture. The results of this survey have indicated that a preliminary reduction of the iron ore to sponge iron, with subsequent melting in the electric furnace would be peculiarly fitted to the needs of the Pacific coast, and considerable progress has been made in experimental work in developing this method to a commercial basis.

A rapid and accurate method for the determination of metallic iron in sponge iron has been developed.

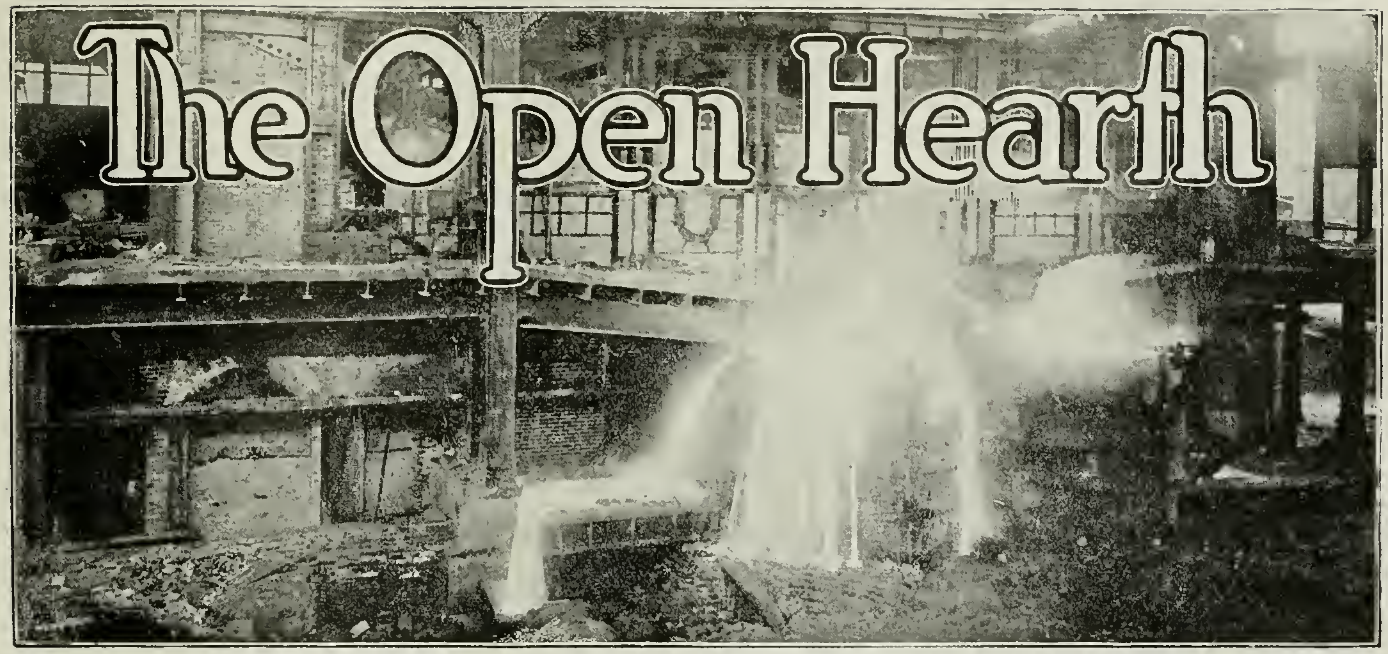
VOLATILIZATION OF LOW-GRADE AND COMPLEX ORES.

The application of the chloride-volatilization process to the recovery of metals in low-grade and complex ores continues to be one of the major problems being studied at the Intermountain Experiment Station of the Bureau of Mines at Salt Lake City, Utah. The process consists of crushing to the proper fineness; mixing with chloridizing agents, such as sodium and calcium chloride, alone or with other reagents; furnacing at elevated temperatures to effect chloridization and volatilization of the metal chlorides formed, and treatment of the volatilized chlorides to obtain the valuable metals in salable form. Electrical precipitation is the most feasible way of colecting the voatiized fume.

The staton maintains a semicommercial plant that includes a large rotary kiln of the cement type, a Wedge roasting furnace and two electrical precipitators, each with a capacity of 1,500 cubic feet of gas per minute. The station's plant also includes a small rotary kiln in which preliminary testing is conducted before testing in the large kiln. A new type of furnace, in which the ore charge is introduced at the fire end, has been constructed. Resultsindicate that better extractions can be obtained than in other types of furnaces tried.

The treatment of the collected fume continues most important, as the fume from each ore is a problem in itself. A laboratory-size reverberatory furnace for the reduction of lead and copper chloride fumes has been constructed to determine whether continuous feed can be employed without excessive loss by volatilization. During test runs by the use of this furnace careful control of the temperatures, keeping them below 1,150 deg., eliminated much of the loss by volatilization. Investigations were made to determine the feasibility of introducing the metallic chloride fumes through the side of the furnace underneath the surface of the slag, and these experiments proved to be successful. The small-scale tlaboratory experiments indicate practically a complete reduction of lead and copper fumes.

The volatilization process is best suited for low-grade oxidized ores of copper, lead, silver and zinc, and also for the more complex oxidized ores of these metals. Practically complete extractions of lead and copper have been obtained, and the extraction of silver has been from 50 to 90 per cent. Copper ore carrying copper mainly in the form of Chrysocolla is very difficult to volatilize. The volatilization process seems to be particularly adapted to separating lead and zinc in oxidized ores.



The Open Hearth

Roland Gerry, a director of the Jones & Laughlin Steel Company and manager of sales of the cold-rolled department, has been advanced to the position of special sales representative of the company for the United States and Canada, effective February 1. Mr. Gerry will be succeeded by William B. Todd, at present vice president of the Union Drawn Steel Company, Beaver Falls, Pa. Mr. Gerry has been with the company 41 years, rising through the sales department in successive grades to the new responsible position he is about to occupy. Mr. Todd has been with the Union Drawn Steel Company for 20 years, having entered its employ through the mill office in 1901 and been advanced through various departments to the vice presidency.

V V

O. H. Wharton, vice president in charge of sales and also a director of the Crucible Steel Company of America, has resigned.

V V

Charles E. Stuart, secretary and treasurer, Central Steel Company, Massillon, Ohio, has been elected president of the Massillon Chamber of Commerce. Among other new officers of the chamber are E. H. Nelson, general manager Griscom-Russell Company, who was named first vice president, and E. H. Birney, president Peerless Drawn Steel Company, who was elected second vice president.

V V

Edward Francis Carry, president Haskell-Barker Car Company, Michigan City, Ind., recently purchased by the Pullman Company, was made president of the combined concern on January 16. J. S. Runnels, retiring president of the Pullman Company, becomes chairman of the board. Mr. Carry started his car building career at the age of 21, as stenographer for Wells & French.

V V

William P. Chinn, assistant general manager of mines for Pickands, Mather & Company, Cleveland, has been promoted to general manager, succeeding C. H. Munger, who has been general manager of mines as well as secretary of the company, but whose duties at Cleveland have necessitated his full attention as secretary. William A. Rose, chief mining engineer of the company, has been made assistant general manager of mines. Mr. Chinn has been with the Pickands, Mather organization since 1901, prior to which he was bookkeeper at the Elba mine, on the Mesabi range, of the Minnesota Iron Company. Soon after Pickands, Mather & Company took over the mine, Mr. Chinn was made superintendent and four years ago was made assistant general manager of mines. Mr. Rose has been chief mining engineer for the company for the past eight years.

V V

J. A. Connely, manager of the Tampico, Mexico, office of the Petroleum Iron Works Company, Sharon, Pa., effective January 1, became sales manager of the company with headquarters at Sharon.

V V

John H. Mowrey, assistant manager of the order department of the Lorain Steel Company, Johnstown, Pa., for 12 years, has resigned to become associated with his father as junior partner in the John I. Mowrey Coal & Lumber Company, Spring City, Pa. Eighteen years ago Mr. Mowrey joined the Lorain Steel Company as private secretary to Daniel Coolidge in the Philadelphia office.

V V

James H. Hammond, president of the Superior Steel Corporation, Pittsburgh, for 24 years and chairman of its board for the past five years, has resigned from the company, along with three others, Henry F. Devens, formerly vice president and recently special agent for the company; Henry D. Sarge, secretary and assistant treasurer, and Frank D. Frost, assistant sales manager.

V V

Bruce Haines, assistant manager Crawfordsville Wire & Nail Company, Crawfordsville, Ind., has resigned and will become general manager of the Davenport, Ia., branch of the Nichols Wire & Sheet Company, Kansas City, Mo.

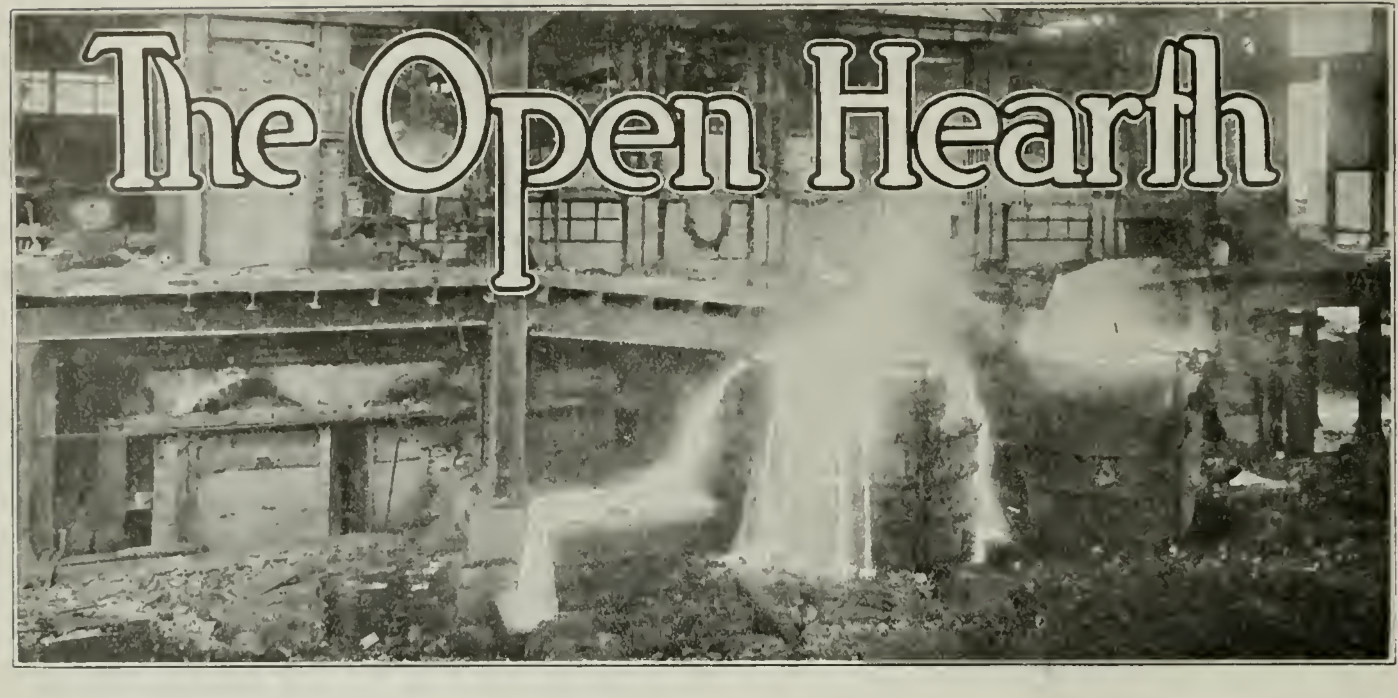
V V

Edward M. Adams will be first vice president and general manager of sales of the Inland Steel Company, succeeding G. H. Jones. Walter C. Carroll will be vice president in charge of sales for the sheet division, and Charles R. Robinson vice president in charge of sales for the rail and track accessories division.

V V

John J. Braut, general auditor Youngstown Sheet & Tube Company, Youngstown, Ohio, retired December 31. He will continue to make his home in Youngstown, where he has resided since 1885. He was appointed auditor of the company in 1911, having previously been in the auditing and accounting departments. He has served with the company for 20 years.

The Open Hearth



George Matin has resigned as auditor of the Youngstown Steel Car Company, Niles, Ohio. He had been previously identified with Price, Waterhouse & Ohio Company.

√ √

F. J. Griffiths resigned January 1 as vice president and works manager of the Central Steel Company, Massillon, Ohio. He has been succeeded as works manager by Benjamin Fairless, who has been plant superintendent. His successor as vice president has not yet been named.

√ √

J. H. Hackenburg, purchasing agent Pressed Steel Car Company, Pittsburgh, has resigned and J. B. Tate has been made assistant purchasing agent and will have charge of the department pending the appointment of Mr. Hackenburg's successor.

√ √

Theodore A. Gessler, for the past 13 years manager of sales of the American Sheet & Tin Plate Company, New York, resigned January 1. Mr. Gessler has been identified with the sheet and tin plate trade since 1898, at which time he became associated with the American Sheet & Tin Plate Company in its New York office. He is succeeded by E. E. Winckler, who has been assistant manager of sales in New York since 1909. Mr. Winckler has been associated with the American Sheet & Tin Plate Company since its organization 22 years ago and previously represented the Cambridge Iron & Steel Company, Cambridge, Ohio, in the east, with headquarters in New York.

√ √

Edward Worcester, who retired as vice president in charge of sales of the National Tube Company, Pittsburgh, on January 1, and who is to make his home in the east and serve the company in an advisory capacity, was tendered a farewell dinner at the William Penn Hotel, Pittsburgh, Thursday evening, January 5, by his former associates in the general offices and by the mill managers. William B. Schiller, president National Tube Company, was toastmaster.

√ √

Lloyd Jones, chief engineer United Engineering & Foundry Company, Pittsburgh, has resigned He has been with the company for about nine years, having become chief engineer when F. C. Biggert was elected president a few years ago. His successor has not yet been named.

Dean R. Wilson has resigned as vice president and treasurer of the Carbon Steel Company, Pittsburgh.

√ √

Judge Samuel L. Black, Columbus, Ohio, was re-elected president at the annual meeting of the directors of the Pittsburgh Tin Plate & Steel Corporation, in Marietta, Ohio, January 6. A. V. Somers was re-elected vice president, treasurer and general manager and O. G. Toner, Eden, Ohio, was named secretary, succeeding A. W. Stump of New York.

√ √

Announcement is made by the Sharon Pressed Steel Company of Sharon, Pa., of the appointment of Mr. William J. Cleary as assistant general sales manager. Mr. Cleary's headquarters will be in No. 1214 Dime Bank Building, Detroit, Mich., and his duties will cover the automotive industry in general.

√ √

Alfred M. Oppenheimer, president of the Apollo Steel Company and a member of the firm of M. Oppenheimer & Company, has been elected a director of the Exchange National bank to fill the vacancy caused by the death of Albert H. Childs.

√ √

William K. Singleton, general manager of sales of the Carnahan Tin Plate & Sheet Company, Canton, Ohio, effective January 15, became identified with the tin plate division of the American Steel Company, Pittsburgh.

√ √

Edward H. Bindley, who is vice president and director of the Pittsburgh Steel Products Company and who has been vice president and director of the Neely Nut & Bolt Company, Pittsburgh, has been elected president of the Neely company in succession to his father, the late John Bindley. At the recent annual meeting of the Neely Nut & Bolt Company R. A. Lackner, secretary, treasurer and general manager of the company, was elected vice presidnt, treasurer and general manager, and Albion Bindly, formerly a director of the Neely company, was elected secretary.

√ √

Frank A. Weidman, who for 12 years was affiliated with the American Sheet & Tin Plate Company, Pittsburgh, latterly as a member of its special agents' department, became identified with the Inland Steel Company, Chicago, on January 15, as special representative.

WITH THE EQUIPMENT MANUFACTURERS

BOWSER & COMPANY ANNOUNCE A PISTON—TYPE "VISIBLE" GASOLINE PUMP

Of five-gallon capacity, this new pump is based on the time-proven principle of piston type measurement and incorporates the famous Bowser water separating filter which extracts all moisture from the gasoline discharged. It also has several new features for the protection of the public.

A bell announces the completion of each gallon measurement of the piston stroke. Thus the customer can check the measurement without watching the pump.

To prevent any misunderstanding between seller and buyer as to the amount discharged, large dial indicators record each individual sale.

But the most interesting feature of this pump to the customer is a sight glass located in the discharge arm which permits him to see the gasoline both before and during discharge. Seeing the gasoline through this sight glass before discharge, the purchaser is absolutely assured of accurate measurement. Seeing the gasoline flow through the sight glass into the hose leading to his car, he is again assured that he is getting all of the gasoline discharged by the pump.

This pump is power operated by air pressure on an auxiliary cylinder which makes the power application absolutely safe in connection with gasoline. It is also arranged for hand operation. All driving parts run in oil, assuring long life and easy operation.

While this new pump adheres to the piston-type measuring principle, for which Bowser & Company have always stood, it affords every virtue of "visibility," with no sacrifice of safety, either to buyer or seller, in the handling of gasoline.

CLEVELAND CRANE & ENGINEERING COMPANY COMPLETES BIG CRANE FOR ARMOR PLANT

One of the most interesting engineering accomplishments for the year is the completion of the huge crane that the Cleveland Crane & Engineering Company of Wickliffe, Ohio, undertook to build for the U. S. Government armor plate plant at Charleston, W. Va.

When it is realized that the runway of this crane is 165 feet above ground—a distance equal to a 15-story office building—and the pit is 100 feet below the floor level, the unusual conditions that had to be met become somewhat apparent

The crane has a span of 104 feet, a capacity of 75 tons, and is driven by two 200-hp. motors. The hoisting speed is 50 feet per minute, fully loaded, and the lowering speed is 100 feet per minute under the same conditions. Very excellent indeed for a crane of this size.

Another interesting feature of its design that engineers should note is its ability to stop a full load descending at the rate of 100 feet per minute in the unusually short space of a single foot.

The crane is of the double bridge drive type and is pulpit operated. Further details will be gladly furnished to those interested by the makers of the crane.

POWER LIFTING AVAILABLE FOR EVERY LOAD MOVING JOB

To provide an electric hoist for every load moving job, small as well as large, is the purpose of the Liftabout, a small general utility hoist recently announced by the Shepard Electric Crane & Hoist Company, Montour Falls, N. Y. The possible uses of the Liftabout are well suggested in its name for it can be applied to advantage in lifting most anything and carrying it most any place. Heretofore many have been under the impression that an electric hoist could be used only for the big, heavy rehandling jobs and that it was not adaptable to the smaller ones. The Liftabout is particularly designed and suited not only to usual lifting jobs encountered in factories, mills and warehouses, but also for the more specialized jobs in apartment houses handling ashes, in ice plants pulling the heavy cans, in slaughter houses expediting the kill and in garages raising chasses. Wherever hand labor is now employed on any job of lifting, carrying and putting down the Liftabout affords a new and far more economical means of doing the work.

In use the Liftabout is most versatile for it can be operated wherever electric current is available and is easily installed on the side of a building, on the ceiling of a basement, or in any point that will bear the weight of a load. One man—any man—can run a Liftabout and with it he can do the work of many, much more rapidly and with far greater efficiency.

On most any load moving job the savings in time and labor that this mechanical means makes will quickly refund its modest initial cost. In developing and marketing this product the Shepard Company has undoubtedly broadened the field where electric hoists may be effectively applied.

SOUTHWARK AUTOMOBILE-BODY PRESS

The Southwark Foundry & Machine Company, Philadelphia, Pa., has recently developed an all-steel hydraulic press, particularly for use in the manufacture of automobile bodies. The press has a capacity of 450 tons. The main ram is located in the lower base, to which are secured the four columns. One clamping platen and one stripper platen are provided.

The stripper platen carries four hydraulic cylinders, which act upon a forged steel plate, which in turn carries 60 stripper pins 1½ in. in diameter and projecting through the clamping platen. The clamping platen itself is a solid steel casting, and is provided with T-slots. The top platen carries eight hydraulic jacks used for clamping, each having a 5-in. ram and 5-in. stroke. The position of the top platen is adjustable, so as to suit various sizes of dies.

The press is controlled by a single-lever operating valve, which first admits low pressure to the four jack cylinders and at the same time low pressure to the main ram. As soon as the dies come together, high pressure is admitted through the steel operating valve, thus forming the work to whatever shape is given it by the dies. The clamping cylinders are controlled automatically from the low-pressure filling tank, and are capable of standing an hydraulic pressure of 5,000 lbs. per square inch. The press has a die space of 7x5 feet, and the vertical opening between the plattens is 18 in. as a minimum and 4 feet as a maximum.

TRADE NOTES

The Boston office of the Cutler-Hammer Manufacturing Company, Milwaukee, has been moved from the Columbian Life Building to Rooms 403 and 404 Harvey Building, Chancy street. Mr. C. W. Yerger is manager of this office.

The R. H. Beaumont Company, Philadelphia, contractors for coal, coke and ash handling systems at boiler houses and gas plants, are increasing their sales force as follows: Mr. P. K. Reed, formerly chief engineer, will enter the sales department and will be located at Philadelphia. Mr. H. D. Williams, a former engineer, will enter the sales department and will be added to the New York office force. The company's Pittsburgh office will move to the Oliver building and will be in charge of Mr. Charles W. Ross. Mr. Ross was formerly New York manager. All of these men are well trained in the fundamentals of coal, coke and ash handling equipment and are prepared to serve plant managers quickly and efficiently in all problems of this nature.

The City of New York Department of Docks has announced the award of contract to the Wellman-Seaver-Morgan Company of Cleveland, Ohio, for 34 cargo handling cranes. This will be the largest installation of dock cranes ever undertaken on this side of the Atlantic. The cranes are to be in operation within one year from date of award of contract. They will be installed on Piers 12 and 13, known as the Pan-American docks, at Stapleton, Staten Island.

F. J. Ryan & Company, Wesley Building, Philadelphia, announce the receipt of the following contracts: Bath Iron Works, Bath, Me., for the installation of Mircs system of fuel oil burning on bar and plate furnaces; Commonwealth of Pennsylvania, Prison Labor Bureau, Huntingdon, Pa., three electric oven equipments to be used in the process of baking of automobile tags; Philadelphia Spring Works, Philadelphia, Pa., one oil fired spring fitting furnace and one oil fired drawing furnace.

Combustion Engineering Corporation announce the opening of a new branch office at 806 First National Bank Building, Pittsburgh, Pa. This office will be in charge of Mr. W. C. Stripe, formerly manager of our Philadelphia office.

The Orton & Steinbrenner Company of Chicago, manufacturers of locomotive cranes, clam shell and orange peel buckets, have made arrangements with Walter Hasendahl, 1213 Fuller avenue, Los Angeles, Cal., to represent them.

Mr. W. B. Wachtler, until recently manager of the Chicago district for the Industrial Bearings Division, Hyatt Roller Bearing Company, has been promoted and transferred to the New York headquarters of the division as engineer in charge of general applications.

The Wilson Welder & Metals Company have moved their general offices and Bush Terminal factory to 132 King street, New York, N. Y. They have installed additional facilities which will enable them to handle their business in certified plastic arc welding metals in addition to Wilson plastic arc metals.

W. S. Rockwell Company announce that Gibbons Bros., Ltd., Dudley, Worc., England, has been appointed their representatives for the British Isles.

The friends of C. H. Davies will be interested to learn that he has severed his connection with the S. F. Bowser Pump & Tank Company, with whom he has been associated the past 16 years. Mr. Davies has already taken up his new duties with the Citrus Products Company of Chicago and will be in charge of advertising and marketing, for which work his previous experience has so well equipped him.

The Hyatt Roller Bearing Company, New York City, has been awarded the contract to furnish Hyatt mill table bearings for the main tables of 34-inch blooming mill of the Allegheny Steel Company, Brackenridge, Pa. The Allegheny Company has for several years operated the tilting tables of the 100-inch plate mill with the Hyatt type of bearing on all table rollers and line shafts.

R. D. Wood & Company, Philadelphia, which for many years has been manufacturing hydraulic machinery and gas producers, will continue active in this business, notwithstanding the recent sale of the equipment of the Camden Iron Works, of which the former were owners. The sale made by the receivers of the Camden Iron Works does not affect the plans of R. D. Wood & Company for continuing in the manufacture of hydraulic machinery, gas producers, etc., in which it has been prominent for more than 30 years, that company states.

The Northern Indiana Gas & Electric Company has decided upon extensive improvements to the several plants of its system and contracts have been awarded for this work to the U. G. I. Contracting Company of Philadelphia. The work includes an outdoor sub-station with switching equipment, three 1667-kva. transformers and a 2500-kw. frequency changer at Hammond, switching equipment and reactors at East Chicago and a 2000-kva. synchronous condenser, outdoor sub-station and switching equipment at Michigan City. At the Fort Wayne gas plant new washer-tar batters and connections are to be installed.

Mutually satisfactory arrangements have been made between the Combustion Engineering Corporation and the George J. Hagan Company of Pittsburgh, whereby the Hagan Company discontinues representation of the Combustion Engineering Corporation. The Combustion Engineering Corporation has opened its own office in the First National Bank Building, Pittsburgh, Pa., and will soon open an office in Cleveland, Ohio, both of which will be in carge of Mr. W. C. Stripe, former manager of the Philadelphia office.

TRADE PUBLICATIONS

The Uehling Instrument Company have recently developed a very efficient filter intended primarily for supplying clean flue gas to their CO_2 recording equipment. The filter proper is made of a very highly refractory material and is remarkably efficient for its purpose.

"The Romance of Wire Rope," by John K. Mumford, is the title of a 137-page illustrated book recently published by the John A. Roebling's Sons Company. The book is written in a popular way, understandable to the layman and in no meaning of the term is it technical. It is historical to a certain extent and is very interesting.

The Pennsylvania Pump & Compressor Company of Easton, Pa., have just issued a new bulletin covering their single stage, straight line, air compressors and vacuum pumps in both belt and steam driven types. In addition to the description of their equipment, the booklet is quite complete as to the table of standard sizes and other essential data. A copy will be sent upon request from the company.

The Mesta Machine Company have issuel Bulletin "U," covering their Una-Flow engines built under Stumpf patents. The bulletin covers Una-Flow mill engines, Una-Flow blowing engines and Una-Flow power engines. A copy will be sent upon request to the company.

Babbitting motor bearings is described in detail in Circular Reprint No. 104, published by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The publication is a discussion of the production of babbitt metal by J. S. Dean, of the Railway Motor Engineering Department, Westinghouse Electric Company, and it contains a number of photographs of equipment used in the manufacture of babbitt metals as well as the results of various tests of samples of alloys.

A new bulletin on the Quigley Fuel Systems, comprising methods of preparing, transporting and burning of pulverized fuels has just been published by the Hardinge Company, 120 Broadway, New York. This bulletin is known as No. 12 and treats the subject of pulverized fuels in a manner never before attempted. One of its distinguishing features is the fact that emphasis is laid upon the methods employed to properly prepare and burn the powdered coal, rather than occupying most of the space discussing the pulverizer.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., MARCH, 1922 No. 3

Discussion on the Disintegration of Blast Furnace Linings

This Is a Discussion of an Article Written by P. O. Menke on This Subject and Published in the February Issue of The Blast Furnace and Steel Plant.

By RAYMOND M. HOWE[*]

THE first article on this subject appears to have been written by John Pattinson in 1876.[†] The furnace involved was 85 feet high and 27 feet in diameter at the boshes. After being in blast five years the top brick became contaminated with carbon and disintegrated. Upon examination of the lining it was found that the discolored, disintegrated brick were in a zone found from 35 to 67 feet above the hearth. Immediately below them the brick were hard and porcelain-like in appearance. This zone extended from 22 to 40 feet above the hearth. Analyses of samples taken from the different sections follow. The water-soluble portion found in the sample taken 39 feet above the hearth had a composition of approximately (See analysis 4, Table I):

Silica	.50
Lime	.04
Potash	.78
Soda	.20
Potassium chloride	6.19
Moisture	1.03
Total	8.74

The carbon deposits consisted of 84.9 per cent carbon and 15.1 per cent. ash, most of which was oxide of iron. (See Table I.)

Judging from Pattinson's statements the conditions in the furnace might be analyzed as follows:

The charge contained appreciable amounts of alkali (probably as chlorides) which volatilized in the vicinity of the bosh. These chlorides either permeated the lining in the hotter portions, condensed on the cool portions, or passed out of the furnace.

Where the temperature conditions were favorable, the chlorides behaved in the usual way and reacted with the iron to form potassium oxide, sodium oxide and volatile ferric chloride. The soda and potash then reacted with the fire-clay to form a dense porcelain-like body having a composition similar to that of true porcelain (see analysis No. V).

TABLE I.

	I. Original Lining.	II. Section 67′ Above Hearth.	III. Section 45′ Above Hearth.	IV. Section 39′ Above Hearth.	V. Section of Vitrified Portion.
Silica	55.70	55.60	55.67	47.60	37.07
Alumina	35.50	35.40	30.00	26.47	23.18
Ferric oxide	4.00	2.67	3.00	1.32	.96
Lime	.30	.34	.23	.06	.17
Magnesia	1.21	1.22	.95	.86	.00
Potash	2.60	2.10	5.30	7.54	21.59
Soda	.45	.42	1.67	.76	6.28
Carbon	...	.05	3.24	5.97	....
Carbon dioxide	...	...	...	...	2.17
Water	...	...	...	...	7.70
Water soluble	...	...	...	8.74	...
Total	99.83	99.80	100.10	99.32	99.12

The slightly cooler lining above this was contaminated with chlorides which caused some of the iron to volatilize but which did not react to form a dense hard structure. It was in this zone that the carbon deposition was greatest (see analysis No. IV). The still cooler sections above this were not even penetrated by the alkalies.

Naturally Pattinson concluded that the skin or coat, which extended to about 40 feet above the hearth, protected this part of the lining from the various destructive influences. He also concluded that a low iron content in fire bricks is most desirable, for the carbon deposits build up about iron spots. Furthermore, he suggested the use of very hard, dense top brick as a means of duplicating the impervious coat which he believed to be so favorable to long service.

After finishing his laboratory work, he visited several other plants in order to see whether or not the condition noted by him was rare or one which had been previously overlooked. He found a distorted flue lining, a disintegrated lining, and section near a burst shell, all of which showed excessive carbon deposition at or near the point of failure.

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[*] Senior Fellow, Refractories Manufacturers' Association Fellowship, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[†] J. Pattinson, on carbon and other deposits from the gases of blast furnaces in Cleveland. J. Iron Steel Inst., 8, 85, 1876.

Mr. I. L. Bell discussed this paper and stated that iron causes a deposition of carbon from flue gas. Successive layers are built up from the surface of the iron and exert a tremendous disintegrating or disrupting effect upon the containers.

The chemistry of this phenomenon remained obscure for several years after Bell and Pattinson had made their findings public. In 1891, however, Messrs. Mond and Quincke prepared iron carbonyl by passing carbon monoxide over iron for a period of 6 weeks at a temperature of from 200 to 350 deg. C.[1] This combination between iron and carbon monoxide was observed to be sluggish and extremely sensitive to temperature changes. When higher or lower temperatures were involved, metallic iron, carbon and carbon dioxide were formed.

Thus the penetration of iron by carbon and the precipitation of carbon from carbon monoxide appear to be similar to the penetration of silver by oxygen and of platinum by hydrogen.

This reaction was further studied by Schenck and Zimmerman in 1905.[*] They found that the deposition of carbon from carbon monoxide did not take place in the presence of iron oxide but that the presence of iron or certain other metals was necessary. When such a metal was oxidized by CO it took place in two steps.

$$\mathrm{Fe} + 2\,\mathrm{CO} \qquad \mathrm{Fe} + \mathrm{CO_2} + \mathrm{C} \qquad \text{I.}$$
$$\mathrm{Fe} + \mathrm{CO_2} \qquad \mathrm{FeO} + \mathrm{CO} \qquad \text{II.}$$

They also found that if the partial pressures of carbon monoxide and carbon dioxide in the furnace, taken together, are greater than the critical pressure, then the oxidation of iron takes place with the deposition of carbon. If the pressure is less, carbon can be deposited but no iron will be oxidized.

The critical pressure varies only with the temperature and is as follows:

500 deg. C. = 15 mm.
550 deg. C. = 35 mm.
600 deg. C. = 70 mm.
650 deg. C. = 145 mm.
750 deg. C. = 305 mm.
750 deg. C. = 535 mm.
800 deg. C. = 800 mm.

Mr. F. W. Lurmann discussed the situation in 1898.[†] He showed in detail how all refractory clays contain pyrites, which burn to form iron spots. These spots are the centers for carbon deposition, which takes place at from 300 to 400 deg. C. He had observed that fire bricks (made at the same time) remained strong when used at higher or lower temperatures, while those subjected to blast furnace service at the indicated temperatures disintegrated.

Mr. F. Firmstone described a more recent failure.[‡] In the case under consideration he found that a very good coating had protected the brick up to a height of 40 feet from the bottom, while the bricks above this disappeared entirely. An analysis of this coating, of the original brick and of the protected brick follows:

TABLE II.

	Original Brick.	Coating.	Brick 1" Inside of Coating.
Silica	55.62	40.23	57.63
Alumina	38.55	12.22	31.64
Iron oxide	4.17	11.93	3.73
Lime	.24	10.92	.24
Magnesia	.24	4.31	.11
Potash	.95	9.39	2.59
Soda	.29	8.43	.51
Zinc	....	....	1.51
Zinc oxide	....	....	.59
Total	100.06	97.43	98.55

Firmstone did not discover the presence of soluble salts in any of the remaining lining nor did he discover appreciable amounts of carbon. He did find that the bell was impregnated with carbon and that the protective coating was high in alkali. Therefore, he concluded that the conditions were duplications of those observed by Pattinson.

He stated that the furnace had been stopped several times because of the shortage of coke and that it was badly scaffolded. These scaffolds were responsible for hot and cold spots, resulting in producing a wide temperature range, part of which would favor carbon deposition.

Bernhard Osann[§] does not accept the carbon deposition theory of disintegration but intimates that this is due to the presence of alkalies.

These various opinions might be summarized as follows:

I. Iron (and possibly its oxides) will cause a precipitation of carbon from carbon monoxide at temperatures between 300 deg. and 400 deg. C. This action, although slow, may result in the building up of large carbon deposits (about relatively small centers) and in so doing disrupts the material. The necessary conditions for such deposition and subsequent disintegration prevail in blast furnace tops. Since carbon deposition has been heavy in several of the linings which failed, many authors believe that this is responsible for their failure. Furthermore, they believe that this condition is more prevalent than is generally appreciated.

II. Alkali chlorides are present in many furnaces and penetrate the lining. They then react with the iron present, forming iron chloride, which is volatile. When the temperature is sufficiently high, these chlorides combine with the lining and produce a strong, impervious, porcelain-like protective coating. This coating protects the inner lining from the action of furnace gases, the erosion of the charge and similar destructive influences.

Later publications attribute disintegration to the use of high-barium, high-sulphur ores.[¶] The zinc deposition theory is now advanced by Mr. Menke[–] and circumstantial evidence in its favor is strong indeed. It is interesting to note that Firmstone, in 1903, also reported the presence of zinc in the lining investigated by him; other investigators have reported the presence of metals which, according to Schenck, precipitate carbon.

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[1] Mond and Quincke, Note on a volatile compound of iron and carbonic oxide. Proc. Chem. Soc., 100, 117, 1891; J. Soc. Chem. Ind., 10, 644, 1891.

[*] Schenck and Zimmerman, Study of the equilibrium between Fe, FeO, C, CO and CO_2, Stahl u. Eisen, 6, 1905.

[†] F. W. Lurmann, "Destruction of Blast Furnace Linings by Carbon Separation," Stahl u. Eisen, 18, 168, 1917.

[‡] F. Firmstone, "Alteration of Fire Brick by Furnace Gases," Trans. Am. Inst. Mining Eng., 34, 437, 1903.

[§] Bernhard Osann, —. Stahl u. Eisen, 23, 823, 1903.

[¶] R. M. Howe, Blast Furnace Refractories, Bul. Am. Inst. Mining Met. Eng., 153, 5, 1920.

[–] P. O. Menke, Disintegration of Blast Furnace Linings, Blast Furnace and Steel Plant, 10, 116, 1922.

The appearance of Mr. P. O. Menke's article on blast furnace lining disintegration is particularly significant at this time. Most articles of this nature bring out the fact that the furnace was operated intermittently because of business conditions, lack of coke, or operating difficulties. In fact he mentions that banking, shoveling out or cooling aggravate disintegration which is less noticeable with continuous operation.

Various explanations are made from time to time and in a great many cases careful study reveals that they are simply attempts to attribute the failure to the refractory lining and to detract attention from operating conditions. Experienced metallurgists are content to state that the bursting of a shell is due to an abnormally high coefficient of expansion of the fire brick, forgetting that the coefficient of expansion is one of its most constant characteristics. Another explanation has been based on the assumption that the flint clay in the lining is not always properly weathered, thereby overlooking the fact that an outstanding characteristic of flint clay is that it does not weather.

One statement made by Mr. Menke appears to be worthy of more than passing consideration. He states that they investigated a lining that was apparently in perfect condition, but discovered that only the inner four inches were solid. The remainder of the lining, except one small zone next to the shell, could be crumbled in the hand. This observation has been made before and in fact was described by the writer in 1919. Is it not possible, therefore, that many of the linings in service are partially or totally disintegrated except for the inner and outer zones? This condition could easily exist in normal times without being noticed. In periods of depression, however, the operator examines his linings carefully and perhaps becomes alarmed over conditions that might not be serious. The lining described by Mr. Menke is still in service in spite of the fact that it was so badly disintegrated back of the four-inch inner face. If this inner face were to wear away would not the lime and alkalies penetrate further, react with the brick dust, sinter the soft material into place, and thus maintain a hard inner face of this thickness? If this were not the case soft, and not hard inner faces, would be observed when used linings were examined, for the 1" face would be quickly coroded.

Returning to the discussion of facts, the writer wishes to comment upon certain points mentioned that are of particular interest to the manufacturer of blast furnace linings. Mr. Menke states that their quality has decreased during the past six years due to carelessness on the part of the workmen, that more plastic clay is now being used, that the flint clays are being ground finer, that too much stress is being placed upon producing a smooth brick of good appearance and that the resistance of different brick to zinc fumes should be studied. While he criticises the refractories manufacturer, Mr. Menke is fair in stating that disintegration cannot be due entirely to the inferior quality of the linings.

The manufacturer had no control over the care exercised by his workmen during the past few years, a fact which has been admitted. On the other hand, the workman has never been supplied with such complete information regarding his raw material as at present. If he accepts inferior clay he does so knowingly. It is doubtful, however, if this is being done to any great extent, for a recent study of some half dozen linings revealed the fact that they were of a refractoriness very close to the limit of fire-clay brick. It is also a fact that more plastic clay is not being used. On the other hand, the tendency is to decrease the plastic clay content of the more refractory brick as rapidly as the manufacturer learns how to manipulate the less plastic mixtures.

It is true that the flint clay is being ground finer, especially in the steam-pressed brick. The manufacturer, under competitive conditions, can hardly be held responsible for this tendency, however. The furnace men usually prefer a smooth, uniform brick, that is possible with finer grinding. Furthermore, the tests that are often applied by consumers distinctly favor finely ground, hard-burned, machine-made brick in every respect save spalling, which is unimportant in this service. Coarsely ground hand-made hearth and bosh brick compress 5.5 per cent in the standard load test, while finely ground steam-pressed brick of the same mix compress 3.0 per cent. In the slag test the denser brick is favored in the ratio of 15 to 1, a ratio which does not represent their relative values in service.

There is no question but what the users of refractories are exerting an enormous influence upon the quality of the product produced. If they select linings of fine grind because they are denser or smoother, manufacturers naturally meet their demands. Likewise, if the consumer devises tests which favor a dense, hard-burned, machine-made brick, the manufacturers do not hesitate to supply such a product. It is the consumer's, not the manufacturer's problem, to decide whether linings will be selected by appearance, tests, or service. There is no question, however, that many of the shorter refractory tests give results out of line with service. The manufacturer can call attention to this fact but the consumer after all controls the situation.

Mr. Menke's final statement is with respect to the study of zinc penetration. The writer can only present data as to the absorption of zinc by the retorts in which it is distilled.

Days in Service.	Per Cent of Zinc Lost Through Absorption by Retort.
1	25.79
2	23.78
3	14.37
4	8.77
5	9.24
6	6.81
7	1.70

Were it possible to prevent this absorption, it is probable that the zinc metallurgists would do so.

Editor's Note—The subject of "Disintegration of Blast Furnace Linings," has created considerable interest. We would be very glad to receive and publish any discussion which can be offered on Mr. Menke's and Mr. Howe's papers.

Recent Development In European By-Product Coking

The First of a Series of Articles Dealing with the Various Types of Electric Gas Governors Introduced in Europe—The Governor by Kress Is Described.

By A. THAU

PART II.

WHILE in former years fluctuations in the gas pressure on by-product coking plants were not taken much into account or considered unavoidable, new propositions had to be faced in this connection with the ever increasing use of coke oven gas for domestic purposes, and last but not least with the efforts to better the efficiency and heat economy of the coking plants by an ever increasing use of coken oven gas for varying purposes.

Although the design of the great majority of the apparatus forming a by-product plant has been taken from gas works practice and proportioned accordingly, different conditions altogether were responsible for the need and eventual introduction of new types of governors for which the gas works devices were not applicable.

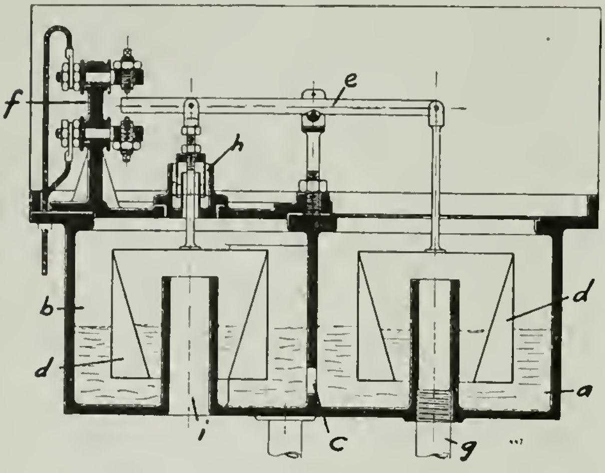

Fig. 1—Float arrangement of governor by Kress.

The usual gas works governors are working by means of a floating bell, either directly or by means of a balance lever upon a bell shaped valve cone or a butterfly valve or influencing the throttle valve in the steam main to the exhaust engine or turbine. Even though such arrangements may work very well on domestic gas plants they fail to give satisfaction if it comes to deal with huge volumes of gas at very irregular pressure and containing a high proportion of tar vapor or dust.

The need for special types of governor has been felt on coke works for two particular purposes. First, for regulating the gas exhausters so that the pressure inside the retorts remains as closely as possible near ± 0. Further need for a special type of governor made itself felt in connection with long distance gas supplies, enabling an adjustment of the pressure at will from the source of supply, i. e., the coke works, and last but not least the application of properly constructed burners to enable the gas to be burned with the utmost efficiency, requiring at the same time a steady gas flow and an even pressure.

With the great distance that is often the case between coke oven battery and gas exhausters and between the coke works and place of delivery of the gas for domestic or industrial purposes, it becomes quite evident that the gas itself is too slow a medium to convey the variations of pressure between considerable distances relative to the gas pressure.

The drawback in applying a purely mechanical operating governor to the regulating of large gas volumes rests with the fact that the distance between the receiver influenced by the variations of pressure and the valve to be moved to compensate them can only be very short because the transmitter between the receiver and the valve is either a rigidly fixed rod, in which case the variations must be corrected at the same spot where they are received, or the transmitter consists of a gas pipe taking the gas from the spot where the variations are received and conveying them to the mechanism operating the valve. One arrangement on works dealing with large volumes of gas is as unsatisfactory as the other. The former is liable to cause the valve to stick and jam with tarry or dusty gas, the latter always lags behind with its compensating movements and the more, the greater the length of the transmitter pipe line. This is due to the resistance the friction causes inside this trans-

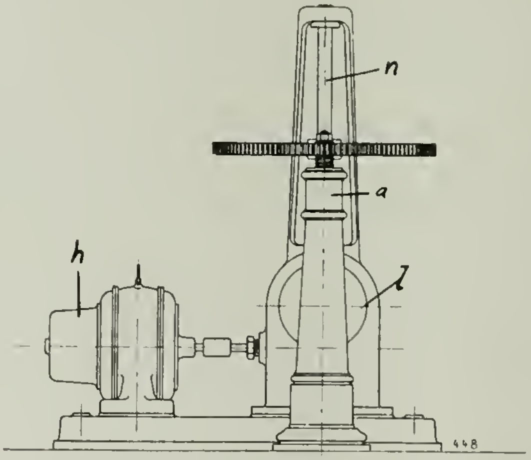

Fig. 2—Regulating valve with electric motor.

mitter pipe. The electric governors in such places fill in a serious gap in that the distance between the spot where the variations of pressure are received and the valve by which they are compensated is unlimited and has no detrimental effect upon the action by transmitting these movements over an electric cable. As the electric current transmits any movements which may be caused by variations of the gas pressure acting upon a sensitive mechanical device quite instantaneously, a perfect construction of electrically operated governors has been eagerly awaited, not only on coke works, but on all plants handling large volumes of gas, such as blast furnaces, producer plants, steel works, etc. The principal types of electric governors brought out in Europe will be briefly described in the following series.

Governor by Kress.

Kress, being a coke works manager, designed his device principally for regulating the suction of the coke ovens. The part of the apparatus directly influenced by the fluctuations of the gas pressure is shown in section in Fig. 1. It is placed near and connected to the collecting main on top of the oven battery and consists of a sheet iron case divided in two compartments, *a* and *b*. Each compartment has about one cubic foot capacity and both are connected together near the bottom by the connection *c*. In both compartments *a* and *b* a bell *d* is suspended, which are on the sides constructed as hollow annular floats. Both bells *d* are suspended loosely like two pendulums from the balance lever *e* on top. The latter projects on one end and reaches between two pretty closely set contacts *f*. The box forming the two compartments *a* and *b* is filled about half way up with water and the gas enters the compartment *a* through the pipe *g* from underneath, while the space above the water around the bell is accessible to the atmosphere. In the compartment *b* the gas enters through a side branch above the water level, affecting the bell from outside, and to prevent the gas from escaping above, the suspension rod carrying the bell is above the compartment *b* provided with cups and water seal *h*. The atmosphere reaches the interior of this bell through the passage *i* from underneath. By these means a very sensitive finely balanced device has been constructed, the effect of which can be adjusted by the variable distance between the two contacts *f* and which is the finer the closer the contacts are set apart and vice versa. A further adjustment is provided by the balance lever *e* projecting on the end opposite to the contacts and receiving a sliding counter weight which can be set to increase or reduce the senstiveness of the instrument. This attachment is not shown in Fig. 1. The cables connected to the contacts *f* are conducted to a switchboard shown in Fig. 4, provided with relays, connected to a dc. circuit and acting upon a little motor geared to the by-pass valve of the exhauster, as shown in Figs. 2 and 3 in part section right angle to each other.

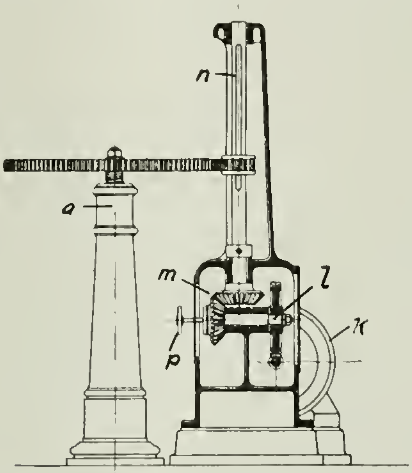

Fig. 3—Regulating valve with electric motor right angle to Fig. 2, showing wormdrive and friction arrangement.

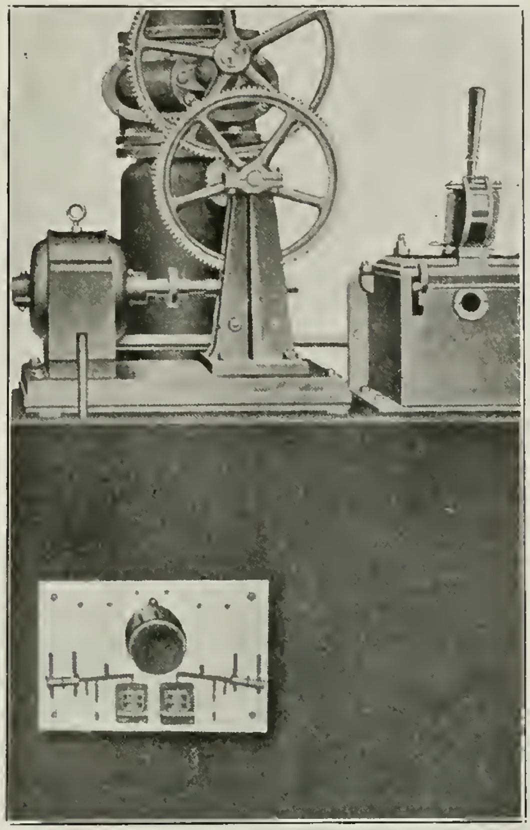

Fig. 4—Horizontal regulating valve with electric motor, also showing switch board with relays.

The motor *k* drives by means of a worm gear *l* and bevel wheels *m* the vertical shaft *n* which is keyed over its whole length and holds a sliding cog wheel, in gear with the toothed hand wheel of the regulating or bypass valve *o*. In case of the relays sticking on the switch board and the motor not being stopped in time, there would be danger of the valve being opened or closed until something would break. To guard against this, the horizontal bevel wheel of the gear *m* is not keyed to the shaft of the worm gear, but only pressed on by a screw tightened by the little hand wheel *p*. Should thus the valve *o* be closed or opened altogether, or any undue strain be caused in moving it, the horizontal bevel wheel of the gear *m* will not turn with the worm wheel shaft and the motor can continue to run without fear of accident. On the other hand, if it is intended to throw the arrangement out of use for repairs or by a failing supply of current, the screw *p* is loosened by hand and the valve *o* can be regulated by the attendant in an instant.

While Figs. 2 and 3 show the arrangement in connection with a vertical regulating valve, it is shown in Fig. 4 in connection with a horizontal regulating valve, the gearing being only slightly different from the former. On new plants the writer found it more convenient to arrange for a regulating valve *o* with the spindle being screwed through the hand wheel. The latter remains then always at the same level on top of the valve column and the cog wheel on the spindle *p* can also be fixed and need not be made to slide.

The arrangement works very well, provided that the contacts on the switchboard are properly attended to, as they suffer much by sparking and scorching. The box *a* in Fig. 1 should have three or four times the depth below the bottom line of the bells than shown, so that the condensed tar can settle down on the bottom and be drawn off periodically without causing the bells to stick as is happening frequently if the box is designed as shown in Fig. 1.

A disadvantage of the last mentioned arrangement rests with the fact that the motor does not stop suddenly and runs thus often too far and is reversed again, keeping thus moving forward and backward until the gas pressure becomes stationary for a time. In all later constructions efforts have been made to overcome every movement of the regulating mechanism the moment the circuit is broken.

Babbitt—A Material For Roll Bearings

Difficulties Encountered in the Use of Babbitt as a Material for Heavy Roll Bearings and Their Remedies—General Characteristics of the Metal.

By W. S. STANDIFORD

THE use of babbitt as a material for rolls does not seem to be used to the extent that it deserves, which is due, no doubt, to a lack of information as to its merits as a bearing metal for roll and pinion bearings. In no line of manufacturing work are journals subjected to rougher usage than in the rolling of iron, steel and the non-ferrous metals as they have to withstand both heat and friction at the same time. For roll necks, brass has serious disadvantages when contrasted with babbitt ones, which are as follows: It has a great expansion when heated, thus causing the necks and end collars of rolls to be pressed together too tightly, the roll neck lubricant getting rubbed off their surfaces quickly and cutting of both metals resulting with a consequent uneven rotation of rolls and bars made differing in thickness and wavy.

It is impossible in rolling mill work to keep all journals from getting heated up to a certain extent, despite the streams of water played upon them, as the material rolled requires to be made into desired shapes while it is hot and plastic, the heat naturally extending from rolls body to their journals. Babbitt, having altogether different characteristics from brass, proves to be a very suitable metal for use in rolling mills, its advantages being of so great a value as compared with brass that it gives the utmost satisfaction when used in mills, due to its great antifrictional qualities as it is of a more greasy nature, this quality allowing it to run much cooler than brass and other metals. As babbitt can be melted in iron ladles over any fire, great rapidity in replacing worn bearings in machinery breakdowns is a most desirable and valuable feature, and also a money saver. In addition, oil grooves can be easily and quickly cut, or if preferred, cast ready made by the workmen using asbestos cord. Uniform bearings are easily obtained in casting when care is used. Babbitt also has the advantage that by use of a portable forge for heating, all work can be done on the spot near the rolls, engines or other machinery, thus saving time by eliminating walking of the workers to and from the job to the lowest possible extent.

This metal deadens noise, and last, but not least, is cheaper than brass. There are a variety of different grades of babbitt on the market adapted for various machine requirements, such as high pressure and fast speed journals, medium pressure and high speed, medium pressure and medium speed and also low pressure and medium speed. High pressure and fast speed metals generally contain more tin and antimony and also a small amount of copper, while the low pressure and medium speed metals have smaller quantities of tin and antimony and also a large amount of lead. Tin, antimony and copper confer hardness to babbitt, so it will readily be seen that those who prefer to make their own metal in various classes of their own machinery bearings can easily regulate its hardness. There are many varieties of babbitt on the market so that any manufacturer who desires to purchase this metal will have no difficulty in selecting a suitable grade for his machines. Personally, the writer thinks that, except for a few special cases, two kinds, one a lead base alloy and the other a tin base one, are sufficient for the average class of machine journals, rolls included. But each metal should be of the highest grade that can be made. Rarely are bearings made entirely out of solid babbitt, except some very small ones, including those made by using die-cast machines; these latter are cast complete with oil grooves in them. They need only to be turned and faced off before using. In general use, babbitt is used only as a lining in bearing shells of cast iron, malleable iron and bronze.

Steel castings were found out by experience to be unsuitable for this purpose on account of warping tendencies when casting strains are removed by machining. Cast iron shells on account of their cheapness and great strength are most commonly used for stationary machines, some malleable ones being in use for the same purposes. This class of shells comes in handy for rolling mills where heavy vibrations are encountered in the rolling processes. The railroads mostly make extensive use of bronze shells so as to insure the completion of their runs. Bronze shells with a babbitt lining are also made use of extensively in the automobile trade.

From the foregoing facts it will readily be seen the esteem in which this metal is held as a bearing metal in various manufacturing lines. Owing to the different set of conditions met with in which roll and pinion journals operate, such as heat and friction, it is necessary to use a babbitt of such a composition as will prove suitable for the work. The formula given below is one that has been found out by long experience to give good satisfaction, it being one that enables the rolls to continue in action for long perods of time until the bearings need replacing.

Formula for Roll and Pinion Babbitt Metal.

1400 lbs.	lead
232 lbs.	antimony
165 lbs.	alloy (tin and antimony mixture)
5 lbs.	bismuth

In making up this formula, there is needed a cast iron pot and also some ladles of various sizes; the latter should be of the self-skimming type, having a welded bridge across the spots so as to prevent dirt and dross from getting poured in with the babbitt. The iron bridge also prevents splashing and enables a good sized stream to be poured. A supply of mandrels, clamps, etc., will also be required by the machinists' or millwrights' repair forces. In making up the formula given, experience shows that it is best to melt and mix the tin and antimony alloy separately from the other ingredients. This is due to the fact of its taking a greater degree of heat to melt them than lead, as it is a matter of importance in melting babbitt (whether it is purchased ready for use or made on the premises) to avoid burning, as the latter produces heavy shrinkage in the lining shells besides reducing its antifrictional qualities.

It is also rendered softer and dirty in texture, all burned bearings wearing out rapidly. Place the tin and all of the antimony, also bismuth, in a crucible; heat until melted. Heat lead separately in cast iron pot until it is fluid, then add the alloy mixture to the lead, stirring vigorously to make a uniform metal and allow the pot to remain on the fire for a while so as to make sure every ingredient is thoroughly melted and mixed, the amount of time depending upon the bulk of metal made. Powdered charcoal or sawdust should be kept on its top surface to prevent oxidation and formation of dross by the air. If it is desired to have a supply of babbitt bars for stock room, use channel irons as a mold, spacing it off into desired lengths by means of short pieces of boards put crosswise in the channel, short sections of suitable sizes as will fit into the melting pot and weighing 50 lbs. apiece will prove a very desirable weight for stockroom shelves.

Channels make very desirable molds for casting ingots of bearing metals, as their weight can be controlled by using channels of varying widths. If it is wanted for general use, leave it in the pot until needed. In rolling mills there are two different types of bearing shells used with cast iron retaining walls to give the desired strength and rigidity, viz: Those that are cast in a solid piece, and also others which are made in two piece sections. The one-piece ones are cast on smaller diameter mandrels having a 1/16-inch taper so as to facilitate their removal when the metal is cold, the babbitt being afterward bored out on a boring mill to such a diameter as will make a neat sliding fit. This style of bearing gives good service on mill pinions, it even being used also on blooming mill rolls.

To give an idea of the amount of babbitt required in large pinion bearings, each one will need 1,200 lbs. of babbitt. The grease slots are cast in them so as to save work. In casting such large and heavy bearings, care has to be taken to put a weight and also clamps around the box and over the mandrel, as the weight of metal pressing against the retaining boards is likely to burst any mold apart if they don't have sufficient strength to resist the hot babbitt's pressure. Air and pouring holes should also be provided so as to get sound castings free from blowholes. The making and handling of babbitt is a very dangerous task, great care having to be taken that no dampness or water should be around while the pouring is being done, as it will explode with disastrous results to workmen around it.

The main drawback in casting large roll and pinion bearings exists in the time taken to cool them so that they will stand handling, but this can be overcome by having four mandrels of the same size for each set of heavy rolls and pouring them one after another. Much work can also be saved by filleting out the mandrels, the former to contain the same radius as those on the rolls. It is also a good plan to have a supply of the finished bearings in the stockroom, as they come handy in emergency breakdowns which at some time or other occur in the best of mills. Blooming mill top roll bearings and other large movable roll bearings in which the wear is extra heavy due to the jerk of rolls when an ingot enters a pass usually have a narrow brass liner with the same radius as the roll necks cast in with the babbitt, the latter metal surrounding and holding it in place. This combination enables all bearings of such rolls to resist wear at their most vulnerable spots. The same result can be achieved by adding a much larger percentage of tin and antimony and also some copper to the babbitt, a reduction or an entire elimination of the lead tending to give hardness.

Increasing the amount of tin and antimony also increases the cost of bearings, especially large, heavy ones. One and two piece shells usually have their linings held in place (to prevent its rotating with roll necks or shaft journals) by means of dovetail grooves, or round anchor studs—sometimes both are in use in cases of heavy rolls weighing 8,000 lbs. or more. The extensive employment of electric dynamos and motors in modern rolling mills calls for a special high grade babbitt in order to make them give the least amount of trouble, day in and day out. These machines are in operation continuously 24 hours so that their bearings get no chance to cool off; in addition, they run in a very hot atmosphere containing a dust composed of very small particles of iron. The latter is produced by the rubbing contact between the rolls surface and metal rolled. For use in such machines, a special babbitt formula is appended, which has been found by years of experience to give excellent results.

Special Babbitt Formula for Electric Dynamos and Motors.

438 lbs.	tin
40 lbs.	antimony
27 lbs.	copper

The above metal is well suited to the high speed and heavy pressures exerted on armature shaft bearings by light and heavy mill motors. As the latter usually have their shafts oiled by revolving rings, these shells for mill motors can be made out of cast iron, although bronze can be employed for this purpose if desired. The cast iron ones are best, owing to the rapidity in which they can be relined as contrasted with those of bronze.

All motor bearings ought to be poured on a much smaller mandrel, the latter having a 1/16-inch taper so as to facilitate ease of withdrawal. They should then be bored out carefully to the desired size. Extreme care must be taken by the workmen to see that no dirt, dross or iron scale from a very rusty ladle gets into this metal while pouring shells, as they will run hot and start to cut both shaft and babbitt, the latter melting in spite of the oil rings conveying oil to them. When the babbitt is worn down in shells, all old metal can quickly be removed from them by first carefully cleaning them from oil and dirt of all kinds and then placing them in a pot of melted babbitt, thus melting it out. By adding old metal (providing that it has not been burnt) to the new, expense can be saved in this direction, as such material will be found to be most useful and again give good service.

Babbitt for motors and dynamos should be kept in a separate place from that used on the rolls, so as to avoid mistakes made by careless workmen using the wrong metal. Another place where this special motor babbitt can be used to great advantage as regards the quickness in which repairs can be made on emergency jobs as well as excellent results obtained in regular work is as a bearing lining for crosshead slides on steam engines, this metal to replace the usual brass ones, the latter requiring a lot of machine work to be done upon them before they are ready for use. The babbitt ones need less work in that respect, thus enabling the machine to be gotten into operation quicker. The proper lubrication of all bearings, whether they are roll necks or engine slides, seems not to be so well understood by the average run of mill superintendents as might be the case, as many seem to think that all that is necessary is to supply machines with grease or oil and let it go at that, the men accepting all wear on journals as an evil which cannot be avoided.

It is true that wear on any bearing and journal cannot be prevented, but it is also true that it can be minimized to the lowest possible extent by using the right type of lubricant for differing sets of working conditions among various classes of machinery Proper lubrication of roll necks is one of the most difficult propositions encountered, which is due to the heat imparted to the bearings during rolling of the hot metal and also to their tightness, that the roller is forced to keep in order to retain the desired sizes while the mill is in operation. It will readily be seen from the foregoing that not only is a lubricant "scraped off by brass bearings, but that excessive pressure is exerted against both necks and roll end collars by the heavy expansion of the heated brass." As a general rule, it will be found by experience that babbitt lined shells will enable all rolls to keep in better shape and last longer before being relegated to the scrap heap, all babbitt metal working better with any of the usual roll lubricants than brass, as babbitt is of itself a much more greasy feeling metal.

The regular lubricant in use on most roll necks is suet, which is obtained from butcher shops, pieces of the material being laid upon roll necks, the heat of the latter melting some of it, which combines to a certain extent with the running water, the latter carrying this greasy mixture between bearing surfaces. Such a mixture has the characteristics of a very thin oil that runs off hot surfaces rapidly and prevents wear to a certain extent. It is well known among lubrication experts, but not by the average run of mill and factory officials, that the consistency of any grease or oil has to be suitable to the weight and rapidity of motion of different machine parts, a lightly constructed machine such as a watch requiring a very thin oil to enable it to run. On the other hand, a thin oil proves to be unsatisfactory for roll and pinion necks, as it is squeezed out by their weight before it can get in efficient work. The suet and water mixture is like a thin oil, it being very costly in the end as regards the length of time that rolls can be operated before they are thrown away in the scrap heap.

Graphite works on an entirely different principle from oil, and it is the best lubricant of all for heavy machinery in rolling mills. To those not acquainted with the properties of graphite and the way that this substance prevents friction, a few pointers about its lubricating qualities will be of interest. The theory and practice of lubrication is to keep two surfaces apart and prevent, as much as possible, their rubbing together, as metals are never smooth. Viewed under a powerful microscope, the most highly polished pieces of metal resemble a nutmeg grater; there are many pin points sticking up, with all pores in metal, tool marks and other irregularities that taken altogether help to produce friction. When the oil on a bearing squeezes out, these irregularities and pin points interlock, with pin points breaking off; this is termed wear. Tiny particles of metal are then carried by the oil into the bearing parts, thus acting as an abrasive. The use of graphite grease containing a large percentage of graphite entirely overcomes this state of affairs.

The graphite first fills up all pores of the metal by being rubbed into them, after which a veneer of graphite is thus placed over the entire wearing surfaces. After this veener of graphite has been obtained, all friction will have been reduced to the lowest possible extent known to mechanics. Another factor that helps to prevent undue wear on the bearings is that the latter, having become coated with graphite as is also the journal, contact is now between graphite and graphite and not metal and metal. It is obvious in this case that all wear is reduced to a minimum. To show the effects of graphite in reducing friction, the following test is instructive. Take two small pieces of paper and lay one upon the other, then try to move the top one over the bottom paper by applying weight and force. It will be found that friction is holding both sections of paper together. Now take some fine flake graphite and rub a little thoroughly into the pores on both sheets of paper, placing the two surfaces together and move them the same as before. You will now find that both sections will move easily one upon the other, and also find out the fact that the more weight you apply, or in other words the more work that the graphite is given to do, the easier both parts move. Unlike oil, graphite cannot be squeezed out under any circumstances, but it remains at all points of contact. This test illustrates the truth that, irrespective of weight, a film of graphite cannot be squeezed out by any pressure, no matter how great the force exerted. In fact, the more weight that is applied the firmer the graphite becomes embedded in all metal pores, the result being that the latter's surfaces are made very smooth. As babbitt is by nature a more greasy substance when compared to brass, the use on roll necks of a graphite grease comes about as near to an ideal mixture as can be expected considering the conditions under which the rolls are worked as regards both heat and friction at the same time.

In respect to the actual work of babbitting boxes, the greatest care in handling this metal should be taken by the machinists' or millwrights' gang so as to get the best possible results, as any carelessness in handling it not only injures a babbitt's quality, but causes the poured bearings to wear out very rapidly and thus makes renewal necessary with its additional expense and loss of time that could be put to better advantage in doing other work by the maintenance forces of mills and factories, as it often occurs that these men have two or more urgent jobs which need attention at the same time.

Another factor in babbitting work is due to the readiness in which the average run of workmen "lay the blame upon a metal's quality," it being said "to be inferior" when, as a matter of fact, the fault is entirely with the workmen and their methods of handling, as the finest quality of metal ever produced can be made to appear as if it were of a cheaper grade and worthless. Mill foremen being, as a general rule, very busy persons, have to depend to a large extent upon what their employes say about a babbitt's quality, they not knowing all the conditions under which it was heated and poured. For the information of this class of men as well as for their workmen who in the vast majority of cases are very fair minded and desire to do effective work and only put the blame upon the metal's quality because of sheer ignorance, this list of the difficulties encountered and the proper remedies to overcome them are appended, which will no doubt also be of interest to all classes of mill and factory men, as a better understanding of bearing metals will be of great advantage to the keeping of machines in action so as to give the least trouble.

Difficulties and Remedies in Babbitting Work.

Difficulty—Blisters on solid one-piece and also two-part bearings.

Remedy—These blisters are caused by a workman putting oil on the mandrel so as to prevent the latter from sticking to the finished casting. They occur mostly on one-piece castings, although the two-part ones will show this defect if oil is used. Their size varies with the amount of oil put on and its viscosity. Rub flake graphite over mandrel's surface that is in contact with hot metal and stop using oil for this purpose. If no graphite is handy, use a very thin coating of white lead and let dry before use. Two-part shells, in most cases, will not need any graphite or white lead on mandrel, as the latter can be easily removed when castings are cold enough to handle. Mandrels should not be taken out of contact with castings while they are hot, as warping and hollow cavities will be the result of such treatment.

Difficulty—High grade babbitt casting has large numbers of hard and soft spots and it has a dirty looking casted surface.

Remedy—Cold babbitt has been solidified in the melting pot and was reheated too rapidly by the workmen trying to hurry along the work. The lighter metals in its composition rise to the surface and become oxidized by their contact with the air, while the heavier ones sink to the bottom. Pouring under the above conditions makes a series of hard and soft spots. Slower heating and more stirring and the use of a layer of charcoal or sawdust on top of the molten mass will produce a uniform casting.

Difficulty—Extreme shrinkage of high grade babbitt castings in bearing shells resulting in a loose bearing; broken anchors and porous areas. This metal will also be found to be oxidized, softened and dirty, and its antifrictional qualities destroyed.

Remedy—The above is one of the cases in which the employes put the blame on the babbitt's being of an inferior grade instead of their own fault in handling. This condition of metal is due to the fact that it was heated and poured at too high a temperature, thus burning and oxidizing some of the more fusible metals. Careful attention to the proper melting point and also to the mandrels and shells temperature along with the use of charcoal on babbitt's surface will obviate this trouble. All babbitt metals of the various grades on the market ought to be heated to such a temperature so that it will just char a pine stick when it is plunged into it and instantly removed. This is a rough and ready shop method, but it is effective just the same.

The proper temperature of a mandrel is also shown to be just right when a drop of water will evaporate quickly from its surface without sputtering, the heat of the mandrel being that of boiling water. Never allow any babbitt of whatever grade used in the mill to get red hot in its melting pot, as it will be ruined. Some workmen when doing work among crowded lines of factory machines locate their fire too far away from the place of work and then purposely overheat the babbitt in ladle and run with it to the machine, expecting it to have the right temperature for pouring and making good castings when they get there. This is bad practice, as it causes the finished work to contain all of the above enumerated defects. The proper thing to do in cases of this kind is to shut down the machine that is next to the one requiring babbitting, then bring the portable forge used in heating the metal as close to the machine as possible so as to avoid burning the babbitt.

For field work of this character it is much better to use a tin base alloy, as it is a metal that is much better suited for field work than a lead base on account of its capability to withstand much more abuse than the lead base material.

Difficulty—The lining has a coarse granular structure looking as if sand had been added to it when melted.

Remedy—The coarse granular structure is due to the babbitt having been heated and poured into lining shells at too low a temperature. The latter should be just right for good results. The too low heating of babbitt is mostly done by "workmen who watch the clock" and wish to quit when the whistle blows, although it occasionally happens through carelessness of workmen desiring to get the work done quickly.

Difficulty—Numerous blowholes in linings, the latter shrinking away from the shells when the metal is cold.

Remedy—This is a case in which the heat of the melted babbitt is correct, but the shells and mandrel are too cold. Proper heating of both shells and mandrel will cure this defect. If the blowholes are still numerous after applying the above remedy, have more air-vents when pouring the hot metal. A lack of enough air-vents will cause the babbitt to bubble and prevent all air from escaping from the hot metal.

Difficulty—Linings soft at tops and brittle at their bottoms, thus wearing unevenly.

Remedy—Shells and mandrel are too hot, the result being that the hot metal is made to cool too slowly, thus allowing the heavier metals to sink to the bottom of lining while the lighter ones remain on top. Proper attention to heating and the other details will remedy this state of affairs.

Difficulty—Spongy and dirty looking castings when metal and mandrel, also shells, are of right temperature.

Remedy—Too much dross was allowed to get into the melted babbitt while pouring. Workmen should always dip the ladle from the bottom of the pot so as to avoid getting too much of the surface layer of metal in pot. Use a self-skimming ladle having a spout so shaped as to pour a round, thick stream instead of a wide, flat one. Such a ladle will prevent, to a large extent, the castings from being spongy and dirty. A broad, thick stream which is poured intermittently and slowly will also produce porous areas and blowholes, the air oxidizing the babbitt's surface. The latter ought to be poured in an even steady stream without surging in ladle, as surging forces dross into the castings. Spongy and dirty castings are also produced by workers throwing too many small pieces of solder in the babbitt melting pot. All small pieces of solder should be saved for future use in soldering and be remelted and made into long sticks, an angle iron mold making a very desirable stick; the lengths of stick can be controlled by clay spacing angle iron into sections.

Difficulty—Too much shrinkage in shells when using a low grade babbitt, temperature of metal, lining shells and mandrel being just right.

Remedy—If much low grade metal is used as a lining, it is best to employ a much smaller diameter mandrel, then take a round-faced hammer and, starting in the center of casting, tap it lightly along its center, extending the blows gradually up both right and left hand sides until the top is reached.

This hammering process spreads the metal sufficiently so as to make it fit the lining shells. Next, bore in a boring mill or scrape them to size. This method, though effective, is not recommended for continuous use, as it wastes too much time and money, but it will do for emergencies when breakdowns occur and a factory is caught without a supply of a higher grade metal which obviates this trouble.

Difficulty—Small two-part split bearings made out of a lead base babbitt have a spongy surface on shaft bearing part. Heating of shells, mandrel and babbitt being correct.

Remedy—This is due to the fact that the shells have been poured with the mandrel on top, thus allowing a certain amount of dross to fill up the part of shell in contact with the shaft; a lead base alloy generally has more dross to it than a tin base one. These small two-part bearings are best poured in a horizontal position, bottom upwards, in the bottom of shell. This method of working has the advantage of making the bearing surface next to mandrel very clean and dense, any impurities or dross being on bottom parts of shells.

In the pouring of large two-part bearings using the same quality of lead base alloy as the small bearings listed above, it is much better practice, in order to get sound castings, to have the shell and mandrel in a vertical position, the front bearing surface facing downwards. This causes any dross that may form to rise to the back end of casting. These large bearings may also be cast bottom upwards like the small two-part ones, but it will be found much more convenient to do the pouring with shells in a vertical position.

Difficulty—Babbitt will not stick to bronze linings of electric motor shells, mandrel hot, metal, shells and temperature being right.

Remedy—The part of the shells where the babbitt touches them ought to be tinned with a thin film of half and half tinners' solder, using a flux of chloride of zinc. The hot babbitt coming into contact with solder surface will melt the film and effect a conjunction between the two metals. Under no circumstances should the soldering flux be added directly to the hot babbitt, as it doesn't work well with it and causes trouble

Difficulty—Workmen trying to make babbitt stick directly to iron shells by tinning the latter, everything being at right temperature.

Remedy—The sticking together of cast iron shells and babbitt cannot be depended upon, as these metals do not alloy at molten solder temperature, it not adhering to shells when both are cold. Should a higher heating of babbitt be tried to effect a junction, the solder will be oxidized and the babbitt's quality ruined, no adherence between iron and babbitt taking place.

Difficulty—A lead base alloy refuses to give satisfactory service on factory machines, with hot metal and shell heat being correct.

Remedy—It is evident from the above state of affairs that too much vibration of moving parts is the cause of rapid wear, a lead base alloy proving much too soft a metal for use on such machines. A tin base alloy containing a higher percentage of tin and antimony will work well, preventing trouble of this kind.

Difficulty—A high grade babbitt wears unevenly and is very brittle, crumbling like granulated sugar in spots.

Remedy—Workmen having burnt overheated babbitt in ladle have attempted to restore the quality by adding new metal to it. Such a mixture should be thrown away as it cannot be restored Care ought always be observed in the heating and handling so as to avoid such a waste of money. Quick and rapid methods of doing repair work is the rule nowadays, and any process that helps to reduce the time taken in getting various classes of machines in operation meets with a warm welcome by all classes of employers, as breakdowns will occur at the most unexpected times. There are also many repair jobs on small machines which, on account of wear on their bearings, require to be done over again at intervals, the rebabbitting of boxes on small engines, nail machinery, etc., being among them. After having had a number of rebabbitting of crankshaft shells that were lined up in the usual slow manner, the writer devised this simple and rapid style of leveling their shafts, it having been used on numerous occasions with good results as regards the working of the finished machine.

The sketch (an end view of shaft and one box) shows clearly how this leveling is done. Drill two holes opposite each other in both boxes to fit small brass machine screws, place shaft in position, using a level to get it straight, turning screws in or out to get it level. The usual methods adopted by workmen to prevent molten metal from running out bearing ends should then be taken. Turning screws as needed enables quick work to be done. The shaft may be removed for warming and put back on tops of screws with the certainty of its being level. These brass screws ough to be left in altogether after pouring of metal as they prevent the threads in cast iron shells from getting filled up with babbitt, thus making rapid work in replacing new bearings when old ones are worn. These screws are easily removed when bearings are worn, as new ones will have to be inserted into the threads for each rebabbitting job.

I will now close by giving another fine electric motor lead base bearing metal formula which will run well in an atmosphere of 90 or 100 deg. F. and give the least amount of trouble. This babbitt is made out of a mixture of lead and antimony combined with a small amount of tin. Lead and antimony are metals that have a chemical affinity for each other, which property causes them to combine in all proportions without any impairment of the antifrictional qualities of either. The antimony also confers hardness to the lead, thus enabling it to stand a higher rate of speed in a rolling mill temperature without abrasions and heatings of the linings taking place, provided that care has been taken by workmen in pouring metal, etc., and dirt is kept out of all bearings during operation of the machine.

Babbitt Bearing Formula for Electric Motor Operation in a 100 deg. F. Atmosphere.

450 lbs. lead
150 lbs. antimony
6 lbs. tin

It must not be inferred from the foregoing that the above babbitt is only suitable as a bearing lining for machines working in a warm temperature. As a matter of fact, it will be found to be of great service for motors and dynamos running in ordinary locations. Should any additional toughness be desired, the tin can be replaced with an equal amount of copper, although it will be found that this metal is sufficiently tough to give good results without any addition of copper.

In judging the quality of babbitt, whether it is bought ready made or manufactured on the premises, a good shop way of sizing up its excellence or otherwise, as the case may be, is to examine a bar's fracture when broken. First-class metal should show a fibrous fracture, having no white oxide patches. If any babbitt on fracture contains such patches, it denotes that it has been poorly made and worthless in regard to giving good service in bearings. As a general rule a babbitt with a large tin content will show a lighter surface when broken, as contrasted with a lead base one. All babbitts will streak paper more or less, if they are pressed hard enough upon it; however, the ones that contain much lead will make the blackest marks.

Some mechanics add phosphorous to the babbitt with the idea that it will cause this metal to adhere better to iron shells. Phosphorous has the above effect, but it also has the drawback of causing it to flow very sluggish when pouring and makes the casting full of blowholes. On this account, phosphorous ought not to be added to babbitt, or if used at all, very sparingly. When the rules for doing babbitting work as given in this article are followed, neat and clean castings will be the result, regardless of the grade of metal used.

Electric Motors in the Steel Plant

Electric Motor Breaking as Applied in a Steel Plant to Restrict Speed of Overhauling Load, to Cause Definite Slow Down and to Stop.

By GORDON FOX*

PART I.

THE electric motor may be employed not only to accelerate and drive machinery, but also to decelerate and stop it. A distinction may be drawn between three types of braking. In lowering an unbalanced load as with a crane or a mine hoist, the motor merely restricts the speed and retains the overhauling load within bounds. In an elevator drive or a skip hoist drive the motor often serves to reduce the speed from full running value to a lower definite value as the end of the travel is approached. With some machine tools and in many steel mill applications, the screw down for instance, motor braking is used to bring the motor to a stop. Motor braking may thus be used:

1—To restrict speed of overhauling load.
2—To cause definite slow down.
3—To stop.

Braking may be accomplished, with a motor drive, either by the motor itself or by an external brake. The motor acts by torque electrically developed in a direction opposing the motion. The brake acts mechanically through friction.

The direction of rotation of a direct current motor is reversed by reversing armature connections. The rotation of an induction motor is reversed by interchanging primary phase leads. If armature or phase leads be reversed while the motor is running, the motor will develop torque opposing rotation, bring the rotor to a stop and start it in the reverse direction. This procedure is termed "plugging" a motor.

If a direct current shunt motor be driven above normal speed it will revert into a generator and will tend to deliver power to the electric system. It therefore requires mechanical power for its drive and acts as a drag. In like manner, an induction motor driven above synchronous speed becomes an induction generator, delivering electric power and demanding mechanical propulsion. Braking by the above methods, in which electric power is returned to the electric system, is commonly termed regenerative braking.

If a direct current motor, while running, have its armature disconnected from the line and then short circuited through a resistance, with the field excited, the motor acts as a generator and circulates current through the armature and the resistance. The energy absorbed in the resistance of the armature and its external circuit is translated from mechanical energy by the motor. Braking by this and similar means wherein the motor is converted into a generator dissipating energy in external resistance, is commonly termed dynamic braking.

Having outlined the various methods of motor braking, we will consider a little more in detail the nature of their action. When a direct current motor is running, it generates a countervoltage which opposes and nearly equals line voltage. When the motor is plugged, the countervoltage continues in its previous direction so long as rotation continues. The impressed voltage is reversed by reversal of armature leads. The impressed volts and countervolts are therefore temporarily additive.

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*Mr. Fox is electrical engineer with Freyn-Brassert and Company, Chicago, Ill.

The voltage existing momentarily across the armature and starting resistance in series may therefore be nearly twice line voltage. As the motor slows down, prior to reversal, the countervoltage decreases and lowers this total voltage. It should be evident that, to restrict the armature current at the instant of plugging, a series resistance materially higher than starting resistance, is required. Plugging is often mentioned as a deplorable practice. This is true in the case of control which is designed for starting duty only and which does not provide sufficient series resistance to restrict the plugging current peak to a safe value. It is also true if the series resistance, although suitably provided for plugging, is cut out too rapidly. Plugging as practiced with suitable plugging resistance added to the starting resistance and with features preventing too rapid short circuiting of this resistance, is an entirely commendable practice. A disadvantage of plugging lies in the fact that the motor is not only stopped, but reversed. If it is desired to merely stop the motor it is necessary to cut off the current at exactly the right instant either manually or by a relay or governor. An advantage of plugging lies in the fact that a strong decelerating torque is maintained by the motor down to and through the point of reversal. It may be remarked that the proper value of total series resistance, inclusive of starting and plugging resistance, may be ordinarily approximated by dividing 150 to 175 percent of line voltage by the permissible current peak. Line voltage plus countervoltage usually totals 150 to 175 per cent line voltage, momentarily. It may be noted that if a series motor is plugged from a high speed, the combination of high speed and strengthened field caused by the increased plugging current will greatly increase the countervoltage and consequently increase the momentary voltage peak and plugging current inrush. For such cases a higher plugging resistance is required. This is apparent from the curves shown in Fig. 1 showing speed current characteristic of a series motor with various values of series resistance. The values below the zero line show the plugging current at any speed with the amount of series resistance as shown. Incidentally, it may be remarked that an adjustable speed motor should not be plugged on a weak field. If plugged from high speed, an extreme plugging voltage and current peak will result.

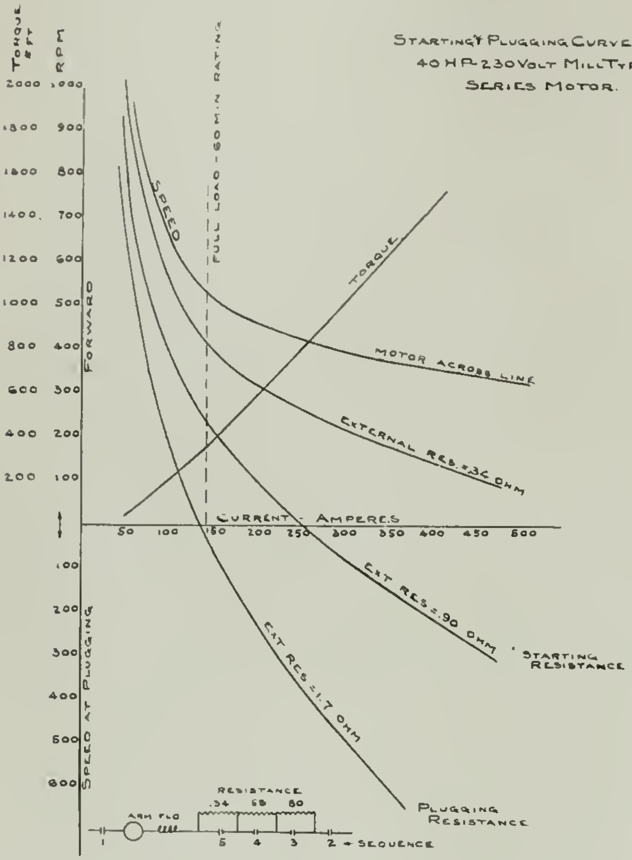


Fig. 1.

The plugging of induction motors is a less frequent practice as they are less commonly used for drives requiring manipulation. The squirrel cage motor draws a high current peak when starting from rest. It will draw a still higher peak if plugged. The high resistance cage motor may be adapted for plugging duty. The wound rotor motor may be and is quite commonly arranged for plugging. In order to restrict the plugging current peak, extra secondary resistance is required just as in the case of the direct current motor. It should also be noted that the voltage and frequency in the rotor circuit are nearly double the values existing when starting from rest. If a wound rotor motor is to be plugged it may require special insulation of the rotor windings and extra clearances at the collector rings and brushes. The same general conditions governing plugging practice apply in the case of both alternating and direct current motors.

All that is necessary to convert a direct current motor to generator action is to increase the speed or strengthen the field to such a point that the countervoltage generated is greater than impressed voltage. Fig. 2 shows the speed load curve of a motor from which it may be seen that a slight increase above no load speed will cause generator action. This applies in the case of a shunt wound motor. A compound motor has a steeper characteristic so that a greater increase in speed is necessary to cause an appreciable generator load. If a compound wound motor is used in connection with overhauling load the series field is generally cut out during running intervals, to give a shunt characteristic. A series motor cannot be employed as such in this capacity as the load cannot be removed without causing excessive speed. A shunt characteristic is necessary to obtain regenerative action without wide speed change.

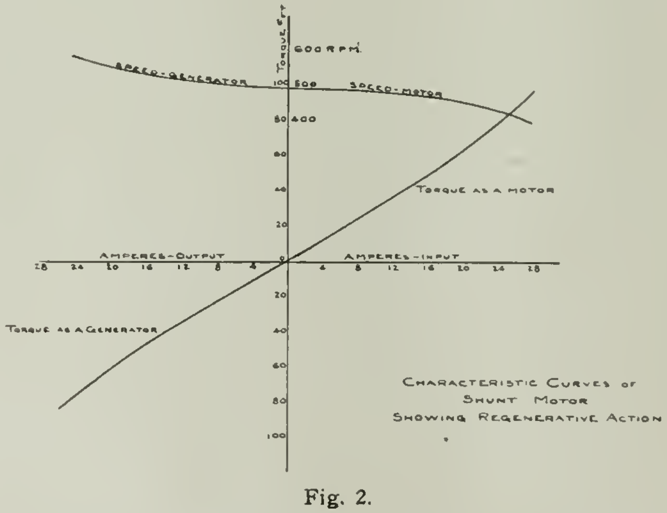
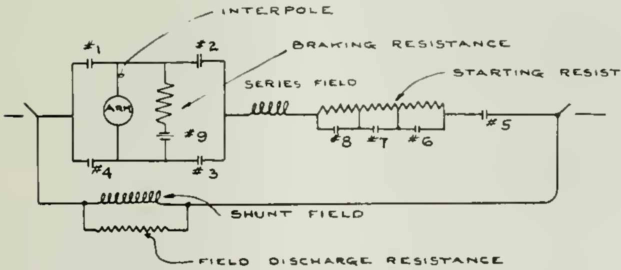


Fig. 2.

An induction motor, driven above synchronous speed, becomes an induction generator. The amount of speed change necessary to produce an appreciable load change depends upon the motor characteristic. A squirrel cage motor with a flat speed load curve will change from motor to generator action with a relatively small speed increase. A high resistance cage motor or a wound rotor motor with external resistance in circuit will not produce effective generator action except as a result of a considerable speed increase. This is of particular interest in connection with electric elevators where a flat characteristic is desirable for regenerative braking, but where considerable secondary resistance is necessary to produce the desired starting torque.

Dynamic braking is employed for restraining, for slowing down and for stopping. These applications will be considered in reverse order. To stop a motor by dynamic braking, the armature is disconnected from the line and then short circuited through resistance. The braking current is proportional to the voltage generated in the armature. This, in turn, is proportional to the speed and the field flux. The current is also inversely proportional to the resistance of the armature and external circuit. The braking torque is proportional to the armature current and the field strength. Dynamic braking can be quite readily accomplished with a shunt or compound wound motor, the braking field being supplied by the shunt winding. Fig. 3 shows the principle connections of a reversing control for a compound wound motor, with dynamic braking used for stopping. Note that the series field should be omitted from the braking circuit, but the interpole should be included in the circuit. In the case of the adjustable speed motor care must be exercised not to brake rapidly from a weak field and high speed. If the field is rapidly strengthened at the same instant that the armature is shorted through the braking resistance, excessive voltage and current will obviously result. This occurrence is prevented in some magnetic controllers by a relay which prevents strengthening the field faster than the braking current flow permits. To obtain effective dynamic braking on a compound wound motor a liberal shunt field winding is necessary to supply a stiff field. To obtain effective braking with a weak shunt field, excessive armature current is required to develop the desired torque. It should be noted that, with any type of motor, as the motor slows down the countervoltage and current fall off so that the braking effect reduces to a low value at low speed. Where it is desired to maintain the braking torque, the braking resistance may be diminished in steps as the motor slows down.



RUNNING - CLOSE #1 & #3 OR #2 & #4 ALSO #5-#6-#7-#8 IN SEQUENCE

BRAKING - CLOSE #9

Fig. 3—Principle connections for reversing dynamic braking control for D.C. compound wound motor.

Dynamic braking cannot be obtained on a series motor in the same way as with a shunt or compound wound motor. Dynamic braking to stop a series motor can be obtained, however, by disconnecting the motor from the line and reconnecting armature and field in series with resistance. The result is a severe cumulative braking action and the armature current tends to reach a high value if not properly restricted by resistance. The braking current, flowing through the series winding, serves to supply the field flux. The braking voltage builds up from residual and is thus cumulative, as already mentioned. It should be noted that if the armature and series field were disconnected from the line intact and shorted through resistance, the direction of flow of braking current through the series field would be opposite to its normal flow. The series field would immediately kill the residual magnetism and no braking would result. It is necessary to reverse the series field (or armature) so that the braking current will flow through the series winding in the same direction as the motor current, thus building upon the residual. Fig. 4 shows one scheme of connections used for this purpose.

SEQUENCE OF CONTACTORS

SWITCH	FORWARD							OFF	REVERSE						
	POWER			BRAKE					BRAKE				POWER		
	3	2	1	1	2	3	4		4	3	2	1	1	2	3
1	O	O	O						O	O	O	O			
2				O	O	O	O						O	O	O
3				O	O	O	O						O	O	O
4	O	O	O						O	O	O	O			
5	O	O	O										O	O	O
6				O	O	O	O		O	O	O	O			
7	CLOSES FOR SLOW DOWN ON OVERTRAVEL												CLOSES FOR SLOW DOWN ON OVERTRAVEL		
8	O	O			O	O	O		O	O	O			O	O
9	O					O	O		O	O					O
10	O						O		O						O

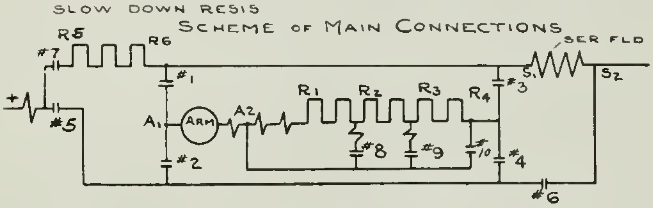


Fig. 4—Connections of series motor with dynamic braking control.

Dynamic braking is more simply accomplished with shunt or compound wound motors. Dynamic braking with the series motor has one distinct advantage, however, in that the braking effect is obtained independent of any outside source of power necessary to excite the fields. Series braking is therefore best suited to such applications as the man trolley drive of a coal or ore bridge. In case power fails as the man trolley approaches its limit of travel, the braking is nevertheless effective, provided the control is such that the braking circuits remain closed.

(To be continued)

NEW METHOD FOR MEASURING PRESSURES IN EVACUATED INCANDESCENT LAMPS.

In one of the papers to be presented at the Meeting of the American Electrochemical Society, April 27, 28 and 29, Dr. Duncan MacRae of the Westinghouse Research Laboratory describes a new method for determining the pressure in a tungsten vacuum lamp. The principle is extremely simple and more accurate than the approximation that has heretofore been made by the well-known use of the induction coil. Dr. MacRae measures the pressures by a McLeod gauge.

Air Required For Combustion of Gases in Steel Plants

A Simple Means of Determining the Amount of Air Required for the Combustion of Various Gases from the Btu. Content of the Gas. Especially Adapted to Steel Mill Furnaces.

By R. T. HASLAM and A. F. SPIEHLER

IN furnace design, especially in furnaces using gaseous fuel, the estimation of the air requirements to obtain the desired results has been a tedious, if not difficult, calculation. It is not usually recognized that there is a direct relation between the Btu per cu. ft. of gas and the air required to burn one cu. ft. By use of this relationship, the determination of air quantities required becomes a rapid and simple calculation.

Table I shows the Btu per cu. ft. and the air required to burn one cu. ft., for several pure gases, combinations of which form almost entirely the combustible components of commercial gases, both natural and artificial. Fig. I shows these points (delta) plotted, Btu vs. cu. ft. air. It will be noted that these points lie along a straight line.

Since this relationship holds for pure gases it should also hold for commercial gases which are nothing but mixtures of these pure gases in different proportions plus various amounts of inert gases such as CO_2 and N_2, which neither require nor furnish air for combustion. Table II gives representative data for the most important types of natural and artificial gases, and by plotting these points, shown as (theta), on Fig. I, they too lie along the same straight line.

It is a well known fact that when the correct amount of any saturated hydro-carbon is burned completely with one cu. ft. of air, a constant amount of heat is evolved.* Thus, if methane is burnt with one cu. ft. of air, the heat evolved will be the same as when propane or any other saturated hydro-carbon is similarly burned with one cu. ft. of air. Ethylene, an unsaturated hydro-carbon, does not fall exactly on the line in Fig. I, but the deviation is not excessive, and as the percentage of ethylene in gases is usually low, the effect of its deviation on commercial gases is negligible. The other unsaturated hydro-carbons, propylene, etc., also deviate, but not as much as ethylene, so in this case the result is again negligible. The only other constituents of any importance in commercial gases, which are not saturated or unsaturated hydrocarbons are hydrogen (H_2) and carbon monoxide (CO). Fortunately, the points for these two important constituents fall along the line, making the relationship complete. Acetylene deviates so widely from the line, that it must be called an exception. Consequently the relation holds for all commercial gases except acetylene.

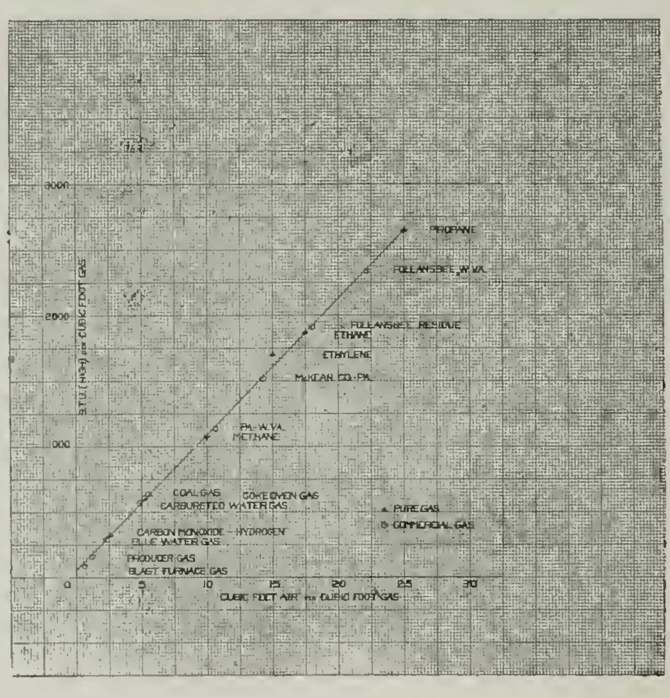


Fig. 1.

Fig. I shows that when Btu per cu. ft. of gases are plotted against the cu. ft. of air required, a straight line results, thus allowing a simple formula to connect one with the other. The general equation for this type of line is of the form $y = a + b X$, and for this line in particular the equation becomes

cu. ft. of air theoretically needed to burn 1 cu. ft. of

$$\text{gas} = 9.67 \frac{\text{Btu}}{1{,}000} - .53$$

where, Btu equals higher heating value in British Thermal Units per cu. ft. of combustible gas.

A rough approximation of this formula for quick estimates is—cu. ft. of air theoretically needed to burn

$$1 \text{ cu .ft. gas} = \frac{\text{Btu}}{100} - .5$$

This formula gives the cu. ft. of air theoretically required to burn one cu. ft. of any gas, but as some excess air is always used, the true amount of air required can be obtained by merely adding to the value found, the percentage excess air considered necessary for any particular operation.

This formula also shows that for a given heat effect, the amount of air required is constant, irrespective of the gaseous fuel used. That is, if a million Btus are desired per hour in a furnace, the amount of air required for this effect is the same whether producer gas or natural gas is used, thus no change of air supplying equipment is needed for a change from one type of gas to another. This assumes the efficiency in the use of each gas is the same.

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*Thornton Rule.

This formula is particularly useful because Btu data on gaseous fuels is always either available or easily determined and from this the air required per cu. ft. of gas may be calculated easily. As the total heat required is also usually known the total cu. ft. of air and cu. ft. of gas required are readily determined.

TABLE I.

Pure Gases.

Gas.	Btu/cu. ft. (high)	Cu. ft. air required (theoretical)	Source of data.
Propane C_3H_8	2650	25.0	Landolt-Bornstein
Methane CH_4	1070	10.0	"
Ethane C_2H_6	1870	17.5	"
Ethylene C_2H_4	1710	15.0	"
Carbon Monoxide CO	322	2.5	"
Hydrogen H_2	324	2.5	"

TABLE II.

Commercial Gases.

Follansbee, W. Va. (Nat.)	2351	22.17	B. of M.	T P.	10
Residual Follansbee (Nat.)	1913	18.03	"	"	
McKean Co. Pa. (Nat.)	1519	14.28	"	"	158
Pa. W. Va. (Nat.)	1132	10.64	"	"	10
Coal Gas	632	5.52	"	"	
Carbureted Water Gas	572	4.89	"	"	
Blue Water Gas	299	2.32	Actual Analysis		
Producer Gas	154	1.21	"	"	
Blast Furnace Gas	86	0.68	"	"	
Coke Oven Gas	607	5.24	"	"	

The Possibility of Improved Methods of Rolling Sheet Steel

Author Does Not Think That a Continuous Sheet Mill Is Impossible—However, He Believes Extensive Scientific Experiments on the Problem Should Be Conducted.

By SUMMER B. ELY, Professor of Commercial Engineering,
Carnegie Institute of Technology, Pittsburgh, Pa.

PROBABLY the first iron plates were made by hammering and must indeed have been a crude production. About the year 1725 or 1730, however, rolls seem to have come into use, although it was a number of years later before anything resembling a thin sheet was made; yet from that day to the present time the same general type of machinery has been used for rolling sheet steel. To be sure, our sheet mills of to-day compared with the early ones would appear giants in size and strength; yet, after all, what real difference is there except this increase of size and strength? Why have we no automatic mills to turn out sheet steel, or at least automatic devices to reduce labor? This is the question asked by everyone who is familiar with the machinery and methods used in the manufacture of heavier steel products, such as billets, bars, rods, plates, etc. We have no continuous sheet mills, we do not even use roller-driven tables, automatic guides, etc. Practically everything is done by hand.

This statement may need a little qualification. Occasionally we do come across some small devices in use; such, for instance, as a hinged or pivoted table to assist the catcher in returning the pack over the top of the rolls to the roller. This particular device does not save any labor in the sense of fewer men being employed; it is merely a help to the catcher. Some devices, such as shifting tables and auxiliary attachments to cold rolls, may have a tendency to cut down the labor force; but, after all, such small helps as these are not real changes in the machinery of sheet rolling, and, furthermore, are far from being universally used. Many plants, probably most plants, do not use such devices; or, if they do, only an occasional mill in the plant is thus equipped.

It would seem, however, as if some device might be gotten up to cut down the number of men needed about a sheet mill. A mechanical catcher, for example, which would automatically catch the pack of sheets as it came through the rolls, lift it up, and return it to the roller. Such a device would seem to be a mechanical possibility and probably could be made to work successfully. Why has not some such device been worked out, perfected, and sold with each sheet mill as part of its regular equipment?

There are probably a good many answers to this question, but it must ultimately come down to a matter of dollars and cents. What will the device cost and how much will it save? If the saving is enough, it does not make any difference what the attitude of the labor union is, sooner or later the manufacturer will introduce it, as has been demonstrated again and again in other industries. But the fact remains that such devices are not in universal use and it would seem as if the amount of saving was not sufficient to act as a real incentive. However, if the question of saving is in doubt in the case of improvements such as I have mentioned, there can be no doubt of a tremendous labor saving, if a successful continuous sheet mill could be devised. Somebody has made the statement, that any steel product, if enough of it is to be rolled and its size is uniform enough, must ultimately be made on a continuous mill. No other form of mill can compete; and this statement perhaps will come true of sheet steel some day. In the past, many attempts have been made and some very expensive continuous sheet mills have been built; and so, while there have been improvements in methods and practice, yet as I have said, the machinery is much the same as it was 200 years ago.

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*Abstract of paper read before the Engineers' Society of Western Pennsylvania.

There is no doubt that to roll thin sheets of steel or iron is a most delicate operation and its success depends on many things. You occasionally hear a sheet mill roller say that the weather is not right to-day and he cannot turn out a satisfactory product; which simply means that some detail is wrong and he is unable to find what it is. One also hears stories from sheet mill superintendents to the effect that after having the windows of the mill cleaned, the rollers have trouble until they accustom themselves to judge the heat of the steel in the brighter light; and one can readily believe this.

In the manufacture of heavier steel products the temperature to which they are heated are high, comparatively, and there is some latitude, but with sheet steel the heat must be just right. Even starting with the bar, say, as it comes from the furnace for the first pass in the mill, if it is too cold the scale will not be lifted and this scale rolls into the sheets, making a rough surface and causing the sheets to stick together later when they are rolled in packs. If the sheet mill could receive only bars that were perfectly clean, perhaps if the material were a little too cold no harm might be done, but all commercial bars carry scale and this must be taken into account.

However, if instead of the bar coming too cold from the pair furnace, it is a little too hot, there is still worse trouble. The large sheet rolls will get hotter than the roller anticipated, will expand, and the line of contact between them will not be correct; and, in addition, as the bar is too hot it will be softer than it should be, and will not spring the rolls the desired amount. The consequence of this is that the bar when worked down on the chill rolls will produce a sheet round on the back end—that is, thinner in the center than at the sides—whereas, probably the bar rolled before this had the proper temperature and produced a sheet that was not long in the center, but long on each side, having what the roller calls "horns." A round-end sheet indicates that the rolls are "full" in the middle and horns show that the rolls are "hollow." Now when a circular-end sheet is placed on the top of a horned sheet, reheated and put into the rolls together, the pack will either pinch or run off at the back end—that is, the sheets will spread one from another on the back end of the pack, due to the uneven drawing. And even if the roller, by great care and judgment in adjusting the draft screw, is able to prevent a pinch, the scale which is produced from being too hot will lift only in spots, sinking into the sheets and causing the pack to stick together in patches, so that the sheets cannot be pried apart without tearing.

Everyone familiar with sheet rolling realizes that the rolls must be kept at the proper heat so that they will be kept the proper shape to roll such a thin product successfully. A roller may (probably unconsciously) count on a certain spring to the stand of rolls, and by trial find the proper heat to go with it, so as to keep the shape of his rolls right; and he will watch carefully the size of the horns on each sheet as this is an indication of the shape of the mill. He knows that if he rolls too fast, and does not allow time enough between passes, his rolls will lose their shape. Neither must he roll too slow. Again, sheets always entered at the same place on the roll may cause trouble. He must constantly watch and guard against such things as cold drafts of air blowing on the rolls, and anything that will affect the temperature of the roll. Of late years some of these difficulties have been remedied by burning gas against the rolls to expand them when not in operation, or by blowing steam on working rolls to keep down the expansion.

Another most important factor is the roll-neck friction, and the extent of this is not always realized. For example, when finishing a pack, if one neck of a roll be greased (with hot neck grease) without greasing the other, the pack will always draw a long horn next to the neck that is dry. The reason is that the friction on the ungreased neck is greater and consequently heats and expands the roll on that side. Undoubtedly a large percentage of power is used in overcoming roll-neck friction. I have reason to think it is anywhere from 60 to 90 per cent although there are no definite figures to go on. This is one of the most important things in roll design and yet we have no scientific information on the subject. If we had, it might lead to some radical changes.

On hot-roll sheet mills at work, a blue or indigo color is often observable and this will correspond to a temperature of about 550 degrees F. This temperature will often run higher, although when reaching 750 degrees, showing a gray, the roll is liable to break shortly afterwards. In a perfectly dark room probably 900 degrees F. would give the roll a perceptible red color. Naturally, the roll is hotter in the center than at the ends and the necks are cooler for, although grease is often seen burning on the neck, the temperature at which the grease burns is generally lower than the temperature of the roll as indicated by its color.

In the history of sheet rolling there has been a tendency to increase the diameter of the rolls continually, until today sheet rolls of 30 inches are seen and I understand rolls as large at 32 inches have been used. The larger the roll, the more tonnage can be turned out, as a large roll does not change its temperature as readily as a small one. There is evidently a limit to the size however (aside from practical considerations of handling such heavy rolls), for the larger the roll the more the radiating surface to cause cooling (The fact that the volume varies as the cube and the surface only as the square of the diameter, has only an indirect relation to this problem of cooling). Also, the larger curvature will not draw the steel as much for the same total pressure.

As far as the breakage of rolls is concerned this is apparently due to unequal expansion, and not to the stress of rolling; as evidenced by the fact that rolls sometimes break when the roll is standing still, the roll train perhaps having been stopped for a few moments during the working period.

Considering now the possibility of a continuous sheet mill, it will be remembered that the United States Steel Corporation spent a very large sum of money at Farrell, Pa. A complete plant was built and in it was installed a continuous sheet mill which consisted of a series of stands of ordinary two-high sheet mills in tandem—the sheet passing through one stand after another, never being in two stands at the same time; and the sheets were automatically doubled and matched together in special devices at certain points in the train. This was about 1906 or 1907. It was thought, even if it were impossible to roll the lighter gages such as 26 and 28, that 18 or 20 gage could be successfully rolled. After this mill had been given a most thorough trial it was given up, the mill was dismantled, and the ordinary method of sheet rolling installed.

This is a convincing and definite proof of the great difficulties of sheet manufacture by using our present roll stands in a continuous train. Aside from any other question the difficulty of keeping so many different rolls in a like expanded condition and shape seems insurmountable. The present method of using gas and steam on the rolls which was not known at that time, might have aided a little; but something a good deal more certain than this must be devised if light gages are to be rolled in this manner. Possibly the heavier gages, say, 10 and 12, could be made in this way, but we already have satisfactory mills of a different type for this purpose and we would be no further along towards automatically rolling light-gage sheet steel.

Some method of absolutely heating the steel to a definite temperature—possibly some form of electric furnace—and some way of keeping the shape of the roll must be devised. Rolls have been cast with holes through the center and steam introduced or gas burned inside them; but they have been found inadequate to hold their shape and stand up to the service. The practice already mentioned of using gas and steam on the surface of the rolls is more satisfactory. Perhaps some day rolls will be placed inside a constant temperature furnace, but what would be done about the bearings and other details is a question.

Some twelve or more years ago I visited a continuous sheet mill in the town of Teplitz in Northern Austria. This is an extremely interesting mill and the only one of its kind I ever heard of. There are five stands of two-high continuous rolls, all being alike, having a diameter of 23⅝ inches and a length of 59 inches. In front of this is a small set of three-high rolls, and to the right a larger set of three-high rolls. An eight-inch slab is delivered to the large three-high mill and broken down to three or four inches in thickness. This slab is then cut in half and put into a reheating furnace, the furnace not being shown on the drawing. One of these halves then goes to the small three-high mill and is reduced to 9/32 of an inch (7 mm.) in thickness and then without reheating is put into the continuous stands. This thickness (9/32 inch) is always the same, and the reduction is varied on the continuous mill to give the required final thickness.

The sheet is finished about 60 feet long and is, of course, in all the stands at the same time. Sheets are always rolled singly and never in packs or doubled. They are from 40 to 50 inches wide. The stands are about nine feet from center to center and no idle rolls or automatic tables of any kind are used—simply stationary guides six or eight inches high and a cast-iron plate between the stands on which the sheet slides. The gear train gives the first stand rolls 30 rpm, the next 37.5, then 45, 52.5, and 60 for the last stand. When I saw the mill it was rolling a final product of 12 gage, making a total reduction in the five stands of some 58 per cent (from 7 mm. to 3 mm.).

Several points of great interest present themselves in connection with this mill. The first is the fact that such a thin piece of steel could be in all the five stands of rolls at the same time and not either tear or be crumpled between them. Right here there is a great deal of confusion as to the pull exerted by rolls generally on steel and for this reason I want to digress for a moment. You will remember that a paper on the theory of the rolling-mill was read by Professor W. Trinks,* before this Society. In this he says: "Most people think that the steel is pulled through the rolls with great force. As a matter of fact there is little if any pulling action." This of course supposes the steel free and not held by any outside force.

This continuous mill has demonstrated the fact that not only can the shape of the rolls be controlled but the speeds and drafts among the various stands can be properly adjusted, at least for single sheets as thin as 14 gage.

Another point of great interest is the fact that the back end of the sheet comes out thicker than the front end, due to the rapid loss of heat while in the continuous rolls. To work this mill economically it must work these long lengths and it is their practice to cut the 60-foot sheets into short pieces, and afterwards sort the corresponding thicknesses from the different long lengths together; so that the variation of thickness would not be noticeable to customers.

I was told that the mill was not a great financial success as there was not demand enough to keep running steadily on these particular gages. Furthermore, the engine running the continuous mill was about 1,000 horse-power normal rating and totally inadequate to run the mill satisfactorily. They said they wanted to buy a larger engine but had no money. I never heard whether or not another engine was installed, nor do I know what happened to this plant during the war.

They had experimented very little with trying to roll two sheets in a pack. The furnace lay-out made it almost impossible to do so. However, the little that had been done seemed to show, as one would expect, that the thinner the sheet the greater the non-uniformity of thickness. It would seem that a reversing two-high mill, receiving alternately the hot and cold end of the steel might equalize this thickness and possibly be more satisfactory than the five continuous stands. So the question would naturally arise, what is the best way of rolling 12 and 14 gage. Then too, it would be impossible to take this 12 or 14 gage rolled on a special mill and finish it on the ordinary two-high sheet mill. Shapes of sheets and rolls will not fit and while one or two packs might be rolled with care, the scrap loss would be enormous and this has been tried commercially and failed. It has also been suggested and thought possible to reduce the cost of sheet rolling by starting with the product from a universal plate mill instead of a sheet bar mill. If a universal plate of seven or eight gage and of accurate width were cut to proper size it would be equivalent to doing away with some of the present roughing down process. However, when the price of the universal plate is taken into account there is little or no gain, and, in addition, the difficulty of doing good work has been very greatly increased.

Speaking of a reversing mill, at first thought it would appear that sheets might be successfully rolled in packs on a two-high reversing mill. The condition of the same two rolls in the same relation to each other and the same pack of steel is what we have in the commercial mill now; and certainly, with reversing roller tables, etc., a large saving in labor would result even if the tonnage per set of rolls were not increased. However, it must be remembered that in a reversing mill, first one end of the pack and then the other would be entered, and this thin pack of sheets would have to be first drawn in one direction and then in the opposite direction; and that the two ends of a pack are not alike. So that we really have a very different condition from the ordinary two-high stand.

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*June 1920, v. 36, p. 275.

This sheet machinery problem is a real problem, but to say or predict that a continuous sheet mill, for instance, is an impossibility, reminds me of my friend the physician who said: "A doctor should never tell a patient he is going to die, because, you know, he might get well." And, while the outlook at the present moment is not encouraging, I am one of those who believe the solution will one day be found.

To my mind, the only logical way to approach this problem is from the scientific experimental side. It has been pretty well demonstrated that practice cannot furnish enough information. We need more knowledge of what actually occurs in rolling—what are the pressures, heat distribution, radiation, friction, etc. Who knows what per cent. of mechanical energy is turned into heat during a pass?

When enough data and information are at hand, new ways and means, as always happens, will be indicated. Our way of looking at the old facts will be different and from another point of view. Find out the underlying principles and causes first, and build elaborate experimental plants afterwards—not before, as has been the case in the past.

Heat Treating Steel For Structural Parts

Illustrating Means of Estimating Carbon Content from Microstructure After Annealing—The Comparison of the Effects of Heat Treatment on Various Steels from Mild to Tool Steel.

By HORACE C. KNERR,
Metallurgist-Naval Aircraft Factory.

EXECUTIVES, engineers, designers and mechanics engaged in the production of such specialties as high grade machinery, engines, automobiles and airplanes, seldom have the time to study deeply into the characteristics of their most indispensable material, steel. To many of them it is simply a strong, hard and tough metal of moderate cost, which can be depended upon to meet certain exacting requirements if properly handled. Its strength in tension, compression and shear can be obtained from reference books, and if it is "good steel" it will not be too difficult to work, and the finished parts will stand a lot of wear and abuse without going to pieces. "Heat treatment" is sometimes looked upon by the layman as a sort of mystic ritual whose proper place was once the forge and tool shop, but which has, through bad luck, recently horned its way into the factory proper, and onto the blue print and specification; and long-winded discussions of which have been taking up an inordinate amount of space in hitherto sensible trade journals, along with a lot of weird terms, and photographs resembling a Cubist's idea of a violent earthquake on lower Broadway.

Few who are not actually engaged in metallurgical work have either the leisure or the inclination to undertake a detailed study of the principles and terms used in connection with heat treatment and the microscopic study of the principles and terms used in connection with heat treatment and the microscopic study of the structure of steel. But many who work with steel would be glad to have more light on the fundamentals of this subject, which is now taking so important a place in the manufacture of high grade parts. An intelligent grasp of the principles of heat treatment as a process and of the use of the microscope in judging the merits, quality and condition of a piece of steel is well worth the while of many who do not care to qualify as metallurgists.

Such terms as "critical range, pearlite, ferrite, sorbite, martensite, eutectoid, normalize," etc., frequently appear in papers and discussions on steel, and the man whose training has been along other lines than metallurgy quite naturally finds much to be desired in respect to clearness.

The purpose of the present paper is to attempt a brief and non-technical review of some of the essential points in the metallurgy of steel such as is used in the fabrication of mechanical parts. Tool steels and special alloys will not be discussed, as their field is more complex. The significance of critical points, the nature of various constituents in the microstructure of steel, the influence of carbon content on the microstructure and physical properties, and the effect of common alloys, will be touched upon. Illustrations will be given showing the relation between heat treatment, microstructure and physical properties in some steels of varying carbon content.

STRUCTURAL COMPOSITION OF STEEL

Crystalline Structure.

Steel is essentially an alloy of the elements iron and carbon. Minute quantities of other elements, such as manganese and silicon, are nearly always present, as are also the impurities, sulphur and phosphorus. Manganese is introduced purposely, as it acts as a scavenger for sulphur. The others exist in the raw materials and it is almost impossible to entirely remove them.

The metal, iron, is crystalline in structure. The crystals are generally microscopic in size. Steel partakes of the crystalline nature of iron. When a properly prepared specimen of iron or steel is viewed under a microscope at a magnification of about 100 diameters or over, the crystals can be clearly seen in section. See Fig. 1, practically carbonless iron. The crystals are usually called grains. The term grains as here used should be distinguished from grain as applied to wood. Correctly speaking, steel has not the latter type of grain, although its behavior and the appearance of its fracture may often suggest such a fibrous condition. Hammering, rolling or drawing may distort the crystalline grains, and some-

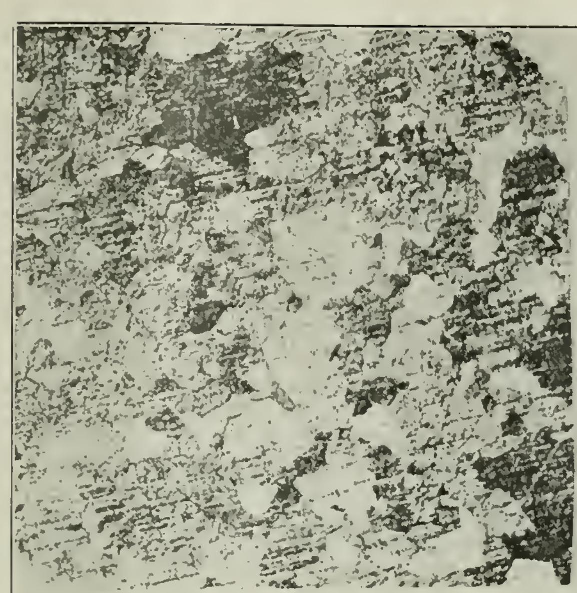

Fig. 1—Practically carbonless iron. Showing grain structure.

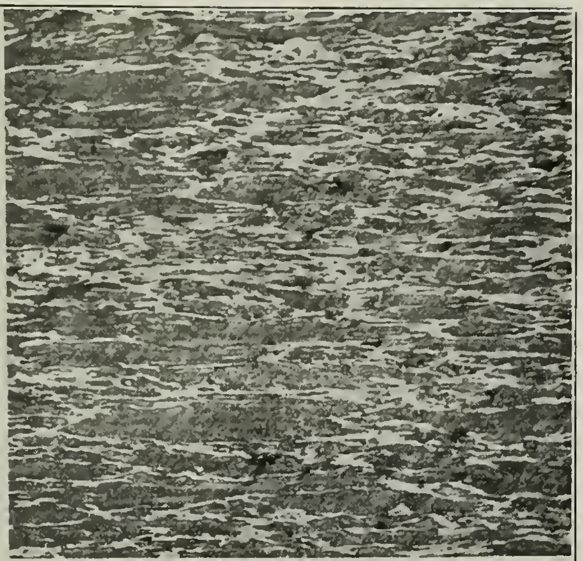

Fig. 2—Longitudinal section of steel bar, as rolled. Grains elongated in direction of rolling.

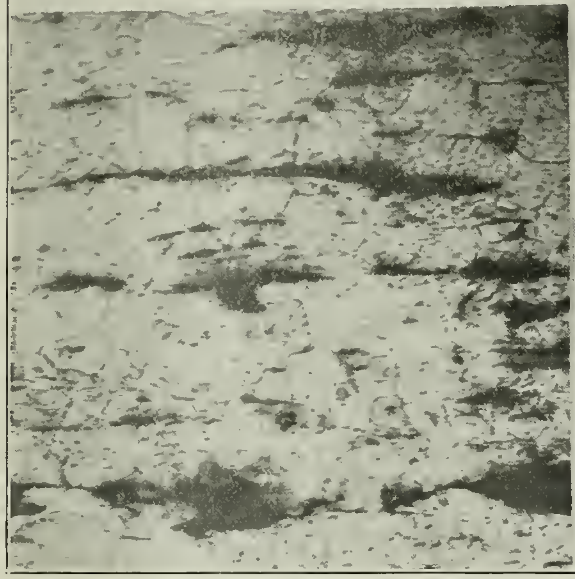

Fig. 3—Longitudinal section wrought iron, annealed. Streaks of slag, which give fibrous appearance. True grains may be seen, and are not elongated.

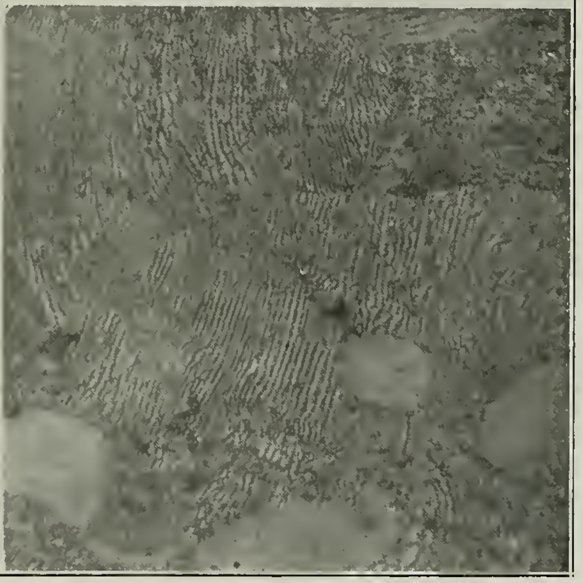

Fig. 4—Pearlite (lamellar) and Ferrite (smooth). Exceptionally large formation.

All specimens etched with 2% Nitric Acid.

All photomicrographs magnified 500 diameters, except where noted.

times greatly elongate them, giving somewhat the effect of grain in wood. This is illustrated in Fig. 2, a longitudinal section through a drawn bar of steel. Wrought iron, due to the presence of streaks of included slag, drawn out in rolling, may also have the fibrous appearance characteristic of the grain in wood. This is shown in Fig. 3, a longitudinal secton of annealed wrought iron. The black streaks are slag, but the crystalline grains can be clearly distinguished, and are not elongated.

Carbon Content.

The hardening properties of steel depend fundamentally upon the amount of carbon it contains. The quantity required is very small, seldom exceeding 1½ per cent in the hardest steels. Steels for structural parts range in carbon content from practically carbonless iron having slow strength but great softness and ductility, up to spring steel containing as much as 0.90 per cent carbon, and certain parts requiring great hardness and resistance to wear, such as bearing surfaces, which may have about 1.0 per cent carbon. The tensile strength of steel increases with carbon content up to about 0.90 per cent, but the ductility or ability to withstand bending or drawing decreases. Both tensile strength and ductility decrease rapidly above 0.90 per cent carbon and such steel is therefore brittle and not suitable for structural parts.

Only steels having a carbon content of not over 0.90 per cent will be discussed here.

Cementite and Ferrite.

The carbon in steel unites with a definite amount of the iron as a chemical compound, the carbide of iron, whose chemical symbol is Fe_3C. This carbide, known to metallurgists as "cementite," is the real hardening constituent of steel. It is an extremely hard substance, being practically as hard as glass, and is also very brittle. There is no free carbon in steel, it all goes into combination with iron as cementite. The remaining iron is free from carbon and is called ferrite. It is very soft and ductile.

Pearlite.

In steel which has been slowly cooled from a high temperature, or "annealed," all the cementite forms a mechanical mixture with a certain definite proportion of ferrite (carbonless iron), in the form of alternate thin layers or laminations of cementite and ferrite, and which, owing to its appearance under the microscope, is known as "pearlite." This is clearly illustrated in Fig. 4.

Annealed steel whose carbon content is approximately 0.90 per cent consists entirely of pearlite and this is called "eutectoid steel." If the carbon content is less than this the steel will consist of a mixture of pearlite and free ferrite. This is called hypo-eutectoid steel. If more than 0.90 per cent carbon is present there will be an excess of free cementite surrounding the grains of pearlite. This is called hyper-eutectoid of steel. The latter condition tends to cause extreme hardness and brittleness.

Metallographic Analysis for Carbon.

The pearlite itself is always of eutectoid composition; that is, it always contains about 0.90 per cent carbon. (The exact amount varies slightly with the composition of the steel and the treatment it has received, perhaps from 0.85 per cent to 0.95 per cent.) This fact affords a convenient and reliable way of estimating the carbon content of a specimen of steel, without the need of chemical analysis. The specimen is fully annealed, a section cut through it, polished by means of successively finer grades of emery and polishing powder, to a mirror-like finish, etched with dilute nitric acid (2 per cent) and examined under the microscope.

If the carbon content is approximately .90 per cent, the structure will be entirely pearlitic

If the carbon content is less than about .05 per cent, as in soft iron, no pearlite will appear.

If the carbon content is 0.45 per cent a structure consisting half of pearlite and half of ferrite will appear, the pearlite being dark and the ferrite bright. If the carbon content is 0.30 per cent the structure will consist of one-third pearlite and two-thirds ferrite, and so on, the proportion of pearlite to the entire mass always being the proportion the carbon content bears to 0.90 per cent. This can be expressed by the formula

$$\text{Per cent carbon} = \frac{\text{Pearlite area}}{\text{Total area}} \times 0.90$$

With practice, the carbon content can be estimated by this method with plus or minus 5 points (.05 per cent).

In specimens whose carbon content is greater than about 0.90 per cent the carbon content can be approximated by estimating the amount of excess cementite which appears as a network about grains of pearlite. This is not, however, of interest here, as such steels are not used in construction on account of their brittleness.

Annealing.

In the foregoing paragraphs steel has been considered in its annealed condition.

Annealing consists in heating the metal above a certain high temperature ("critical range" described below), generally a bright red heat, and causing it to cool slowly, as in the furnace. This leaves the steel with a structure consisting of grains of pearlite, surrounded either by free ferrite or cementite, according to whether the carbon content is below or above .90 per cent, as previously explained.

Heating much above the critical range or holding for too long a time above the critical range causes the grains to enlarge. Coarse grain structure is very objectionable as it tends to weaken the steel and make it brittle.

Normalizing may be considered as a form of annealing. It has been defined as heating the steel slightly above the critical range, and cooling in air. This serves to remove internal stresses in the metal that may have been set up in cold working, and to produce a fine and uniform grain structure.

Fig. 5—Annealed—Heated to 1650 deg. F. and cooled in air. Pearlite—Ferrite.

Yield stress	30,000
Ultimate stress	40,000
Elongation 2-in.	45%
Brinell hardness	100

Fig. 6—Hardened—Heated to 1625 deg. F. and quenched in oil. Sorbite and Ferrite (carbon too low for complete hardening.)

Yield stress	50,000
Ultimate stress	65,000
Elongation 2-in.	25%
Brinell hardness	135

Fig. 7—Tempered—at 850 deg. for 30 minutes. Sorbite passing into pearlite and ferrite.

Yield stress	45,000
Ultimate stress	60,000
Elongation 2-in.	30%
Brinell hardness	125

Fig. 8—Annealed—Heated to 1600 deg. F. and cooled in still air. Pearlite—Ferrite.

Medium (low) Carbon steel. Carbon 0.30%.

Yield stress	40,000
Ultimate stress	60,000
Elongation 2-in.	27%
Reduction of area	55%
Brinell hardness	150

Fig. 9—Hardened—Heated to 1575 deg. F. and quenched in oil. Sorbite with some ferrite. (Hardening not entirely complete due to comparatively low carbon.)

Yield stress	80,000
Ultimate stress	90,000
Elongation 2-in.	15%
Reduction of area	40%
Brinell hardness	200

Fig. 10—Tempered—at 900 deg. F. for 30 minutes. Sorbite, passing into Pearlite and Ferrite.

Yield stress	60,000
Ultimate stress	80,000
Elongation 2-in.	22%
Reduction of area	50%
Brinell hardness	170

Critical Points.

The heating of steel to high temperatures, although considerably below the melting point, causes very important changes to take place in its condition. These internal changes are accompanied by certain phenomena, such as the release or absorption of heat, abrupt expansion or contraction, changes in magnetic qualities, etc.

The transformations for a given steel take place at certain definite temperatures, called transformation points, or more commonly "critical points." Broadly

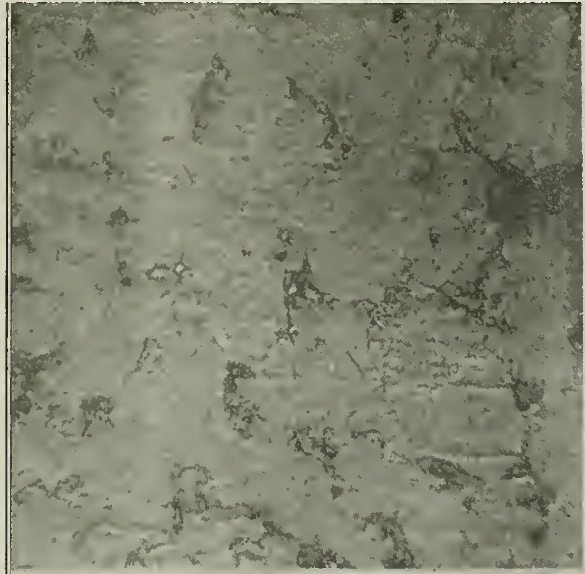

Fig. 5.

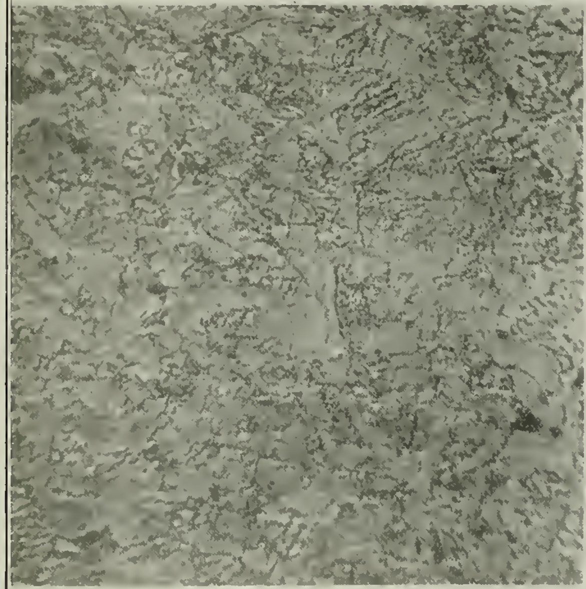

Fig. 6.

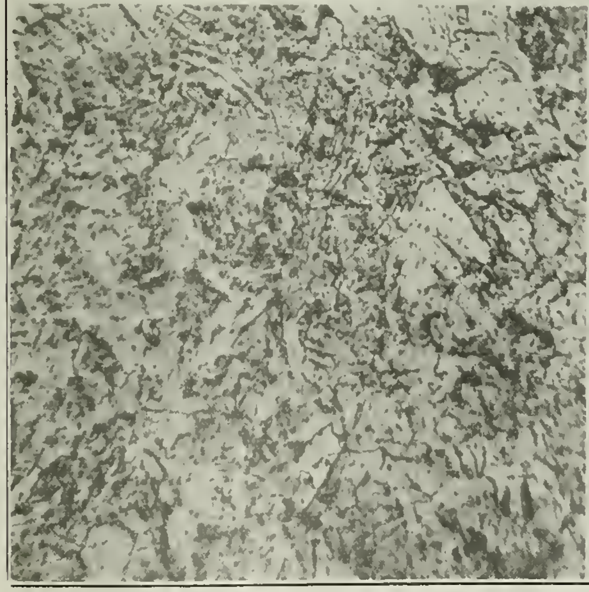

Fig. 7.

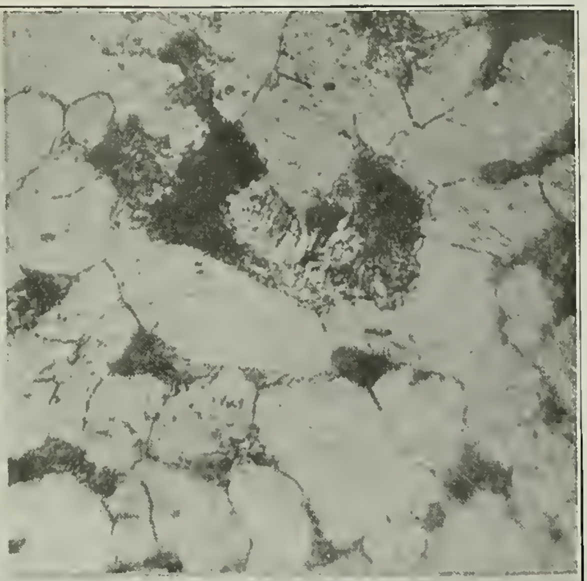

Fig. 8.

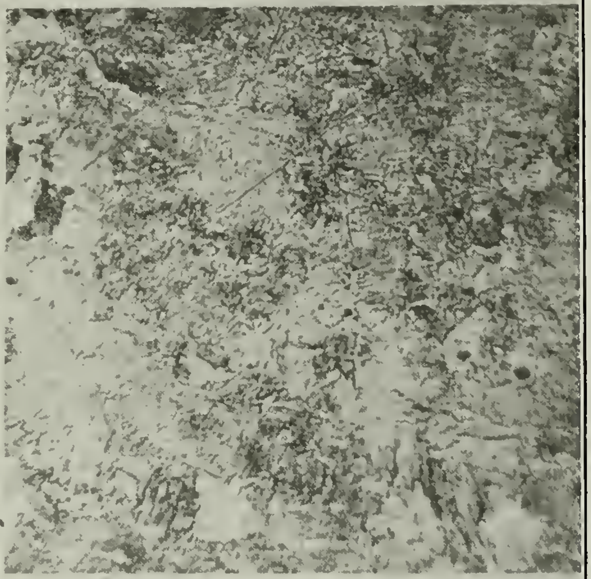

Fig. 9.

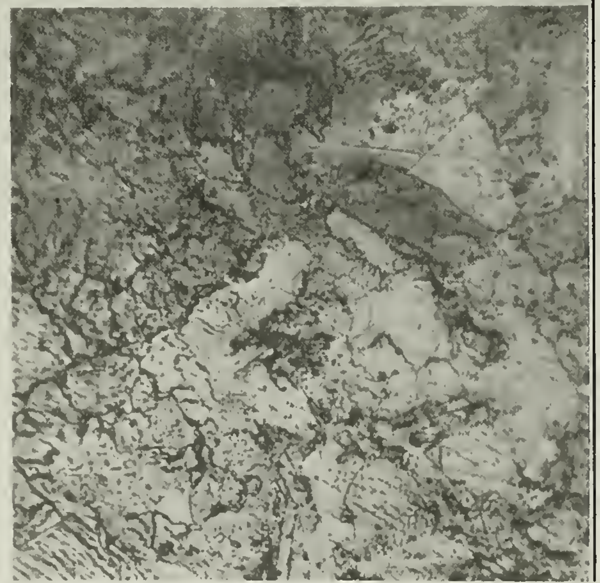

Fig. 10.

speaking, low carbon steel has three critical points, medeium carbon two, and high carbon one. The limits of temperature between which the critical points occur are called the "critical range" of the steel. The position of the points is affected by the chemical composition of the steel and also upon the rate of heating or cooling.

The critical range is lowered with an increase in carbon up to the eutectoid composition, 0.90 per cent carbon. Other elements, such as nickel, chromium, manganese, tungsten, etc., have a strong effect on the critical range, some tending to raise and others to lower it. This will be more fully discussed under alloy steels.

The critical points are reversible on heating and cooling. That is, if certain changes take place in a piece of steel when it is slowly heated to above the critical range, equal and opposite changes will take place on slowly cooling it to below the critical range. For example, on a rising temperature, there will be a sudden absorption of heat, a loss of magnetic properties, and a halt in the expansion of the metal, while on a falling temperature heat will, at a certain point, suddenly be given off, magnetic properties regained, and contraction momentarily cease. The changes on cooling will take place at somewhat lower temperatures than they did on heating, that is, there is a lag in the cycle. The position of the transformation points is affected by the rate of heating or cooling. They will be higher if the piece is rapidly heated, and will be lower if it is rapidly cooled.

Hardening or Quenching.

The hardening power of steel depends upon changes which take place in its condition on heating it above the critical range. Sudden cooling prevents the steel from returning to the pearlitic condition which it has after slow cooling.

When steel which has been heated above its critical range is suddenly cooled to normal temperature, as by quenching in oil or water, a homogeneous mass of fine structure and maximum hardness results. This is very different both in appearance and properties from the pearlite and ferrite obtained by slow cooling. With high carbon steel and certain medium carbon alloy steels this mass will consist of "martensite." Next to cementite, martensite is the hardest and most brittle constituent of steel. It has a structure suggesting a triangular network of needles. Individual grains cannot ordinarly be distinguished. Lower carbon steels when quenched will yield "sorbite," a softer and more ductile substance than martensite, but harder and tougher than pearlite.

Still lower carbon steels will yield a mixture of sorbite and ferrite when quenched. Illustrations of these structures are given further below. Figs. 5 to 10.

Quenching from temperatures lower than the critical range will result in practically no hardening, and if the quenching temperature lies within the critical range the hardening will be partial.

Heating much above the critical range for quenching will produce a coarse structure and tend to cause brittleness and other ill effects.

Accurate control of quenching temperatures, by means of reliable pyrometers, is therefore essential.

Steel which has been quenched is generally too hard and brittle for structural use, and contains severe internal hardening strains set up by the unequal contraction of the mass in sudden cooling. These strains are likely to cause cracks, and must always be removed by the operation known as tempering.

Tempering or Drawing.

Tempering, sometimes called drawing, consists in reheating hardened steel to certain temperatures below the critical range, generally followed by allowing to cool in air.

In addition to relieving internal strains caused by quenching, tempering reduces the hardness and increases the ductility, at the same time lowering the tensile strength of the steel. By varying the tempering temperature from a few hundred degrees Fahrenheit up to the critical range, various combinations from maximum hardness and tensile strength and minimum ductility, to minimum hardness and tensile strength and maximum ductility are obtained.

This is accompanied by corresponding changes in the microstructure.

With increasing temperature the martensite of hardened steel breaks down into the softer and more ductile sorbite, and the sorbite into a still softer mixture of sorbite and finely divided ferrite, and finally, as the drawing temperature reaches the critical range the sorbite resolves into pearlite with the complete seperation of the excess ferrite, as in annealed steel.

Troostite.

In passing from martensite to sorbite, an intermediate condition occurs, known as troostite, and appearing as dark spots on the background or matrix of martensite. The exact nature of troostite is somewhat in doubt, but it is generally regarded as a transitional stage of martensite breaking down into sorbite, or a conglomerate of the two. It is softer and more ductile than martensite, but harder and less ductile than sorbite.

Alloy Steels.

By adding to steel small quantities of certain metals such as nickel, chromium, vanadium and molybdenum, singly or in various combinations, its physical properties can be very greatly improved. The first three are the most extensively used alloys for steel intended for structural parts, and molybdenum is taking an important place. Larger quantities of manganese and silicon than ordinarily present in steel, and other alloys such as tungsten, zirconium, etc., also have important functions for special purposes.

Each of these alloys has its characteristic effect, and the particular amount of each which is the most desirable has definite limits. All of them depend upon proper heat treatment to produce the desired results. This fact is often overlooked by users of steel, to their considerable disadvantage. The effectiveness of the alloys also varies largely with the amount of carbon in the steel.

Nickel may be added economically, up to about 4 per cent. Above this an increase in nickel is not repaid by a corresponding improvement in properties, and in certain quantities is even harmful. The presence of about 3½ per cent of nickel greatly increases both the tensile strength and ductility of a steel of given carbon content after proper heat treatment. As with carbon, the critical range, and consequently the quenching temperature, is lowered with an increase in nickel. Without heat treatment, nickel has very little effect on the properties of steel.

The presence of nickel cannot be detected by means of the microscope, as it goes into solution much as salt does in water, and does not form any recognizable constituent.

Chromium is generally added up to about 1.75 per cent as a maximum, smaller amounts being more common. Alone, it increases the ability of the steel to harden in quenching, but also tends to cause brittleness. It raises the critical range. Chromium is most profitably used in conjunction with one of the other alloys, nickel, vanadium or molybdenum, as these counteract the brittleness found with chromium alone, and great tensile strength and toughness result

Vanadium and molybdenum are somewhat similar in their action, being most valuable as enhancing the effect of another alloy, usually chromium. They are used in very small quantities, 0.15 per cent being customary for vanadium and about 0.25 per cent to 0.50 per cent for molybdenum. Both of them toughen the steel, that is, they increase the ductility for a given tensile strength, and they also increase the tensile strength. Vanadium raises the critical range. Molybdenum has the remarkable and very valuable effect of widening the limits within which it is safe to vary the quenching temperature, so that the heat treatment will be rendered less delicate.

In General.

By the successive operations of hardening and tempering it is possible to obtain the most desirable combinations of hardness, strength, ductility and toughness inherent to the steel in question. The use of certain alloys greatly intensifies the beneficial effects derived from heat treatment. It must be borne in mind that the physical properties obtainable by heat treatment are strictly limited by the chemical composition of the steel itself. It would be impossible, for instance, to impart to low carbon steel the hardness obtainable in high carbon steel, or to make the latter as malleable as the former, or as tough as a particular alloy steel.

Photo-micrographs and data illustrating the effect of heat treatment upon the structure and physical properties of several types of steel used in aircraft construction are given in Figs. 5 to 10 inclusive. (Per cent elongation is a measure of the ductility of steel, that is, its ability to stand deformation without breaking.)

The values of tensile strength and elongation after hardening are given for purposes of comparison only. For the reasons stated, quenched steel should never be used without having been drawn.

It will be noted from the data that, as the carbon content increases, the tensile strength and hardness increase, and the ductility (per cent elongation) decreases for the steel, either in the annealed, quenched or tempered state, and the quenching temperature becomes lower.

The remarkable effect on the strength and ductility of adding 3½ per cent nickel to 0.30 per cent carbon steel is manifest, and it is plain that the effect depends almost entrely upon heat treatment.

Acid Open Hearth Process for Manufacture of Gun Steel and Fine Steel

Detailed Description of This Manner of Work, Giving the Various Steps of Manufacture—Result of Investigations Made by Special Committee as to Difficulties Encountered.

By W. P. BARBA and HENRY M. HOWE

IN Sections 1 to 11 inclusive, we give a condensed statement of our subject, in particular indicating the chief ends to be held in view in conducting the open hearth process for gun steel, while in the remainder of the paper we elaborate this matter.

1. *Composition*—In order to comply with the physical tests of American ordnance specifications, the composition of nickel steel pieces for cannon and shafting should lie within the following limits, the exact composition varying with the part of the gun which the piece in question is to form, whether tube, jacket, hoop, or other.

	Per Cent		*Per Cent*
Carbon	0.35 to 0.50	Manganese	0.50 to 0.75
Phosphorus	below 0.05	Silicon	0.15 to 0.30
Sulphur	below 0.05	Nickel	2.50 to 3.75

For ease of exposition we have assumed a specific carbon content, 0.35 per cent.

The steel should be brought at the moment of teeming† to the desired composition in every respect.

(a) The manganese and silicon must be brought to the desired proportion. In order to do this, the bath should be freed from oxygen as nearly as possible and certainly to a constant degree. This freedom from oxygen is important also for lessening or preventing segregation, blowholes, and structural metallurgical weakness.

(b) Phosphorus and sulphur must be below the prescribed limit, and to this end the stock must be sufficiently free from them.

(c) The chromium and nickel must be within the prescribed limits.

2. The *temperature* must be accurately regulated, for reasons which appear in the following paragraphs.

3. *Segregation* must be restrained, and to that end the steel must be poured at a relatively low temperature‡ and must be free from oxygen.

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*Abstract of paper presented at the New York Meeting, February, 1922, of the American Institute of Mining and Metallurgical Engineers.

†Throughout this paper *tapping* refers to pouring the steel from the furnace into the ladle, and *teeming* or *pouring* to pouring it from the ladle into the mold.

‡This represents American practice. In Section 39, we consider the reasons which favor the opposite course of pouring at a high temperature, as is done in Continental Europe.

4. *Columnar crystallization* must be restrained and the size of the dendrites kept down. To this end the teeming temperature should be relatively low.

5. *Piping Must Be Restrained*—To this end the ingots should be cast with the large end up, and at as low a temperature and as rapid a rate as the ingot sizes and the chemistry of the steel permit.

6. *External Cracking Should Be Prevented*—Here we may note that there are two periods of brittleness. First, when the steel is cooling toward the solidus, and thus is a viscous solid, an intimate mixture of a large proportion of already solid pasty particles and a relatively small proportion of still molten steel. Second, at the blue heat. The tendency in any given layer to crack in this period is often exaggerated by the simultaneous expansion which the deeper seated and slightly hotter layers are undergoing in passing through the recalescence.

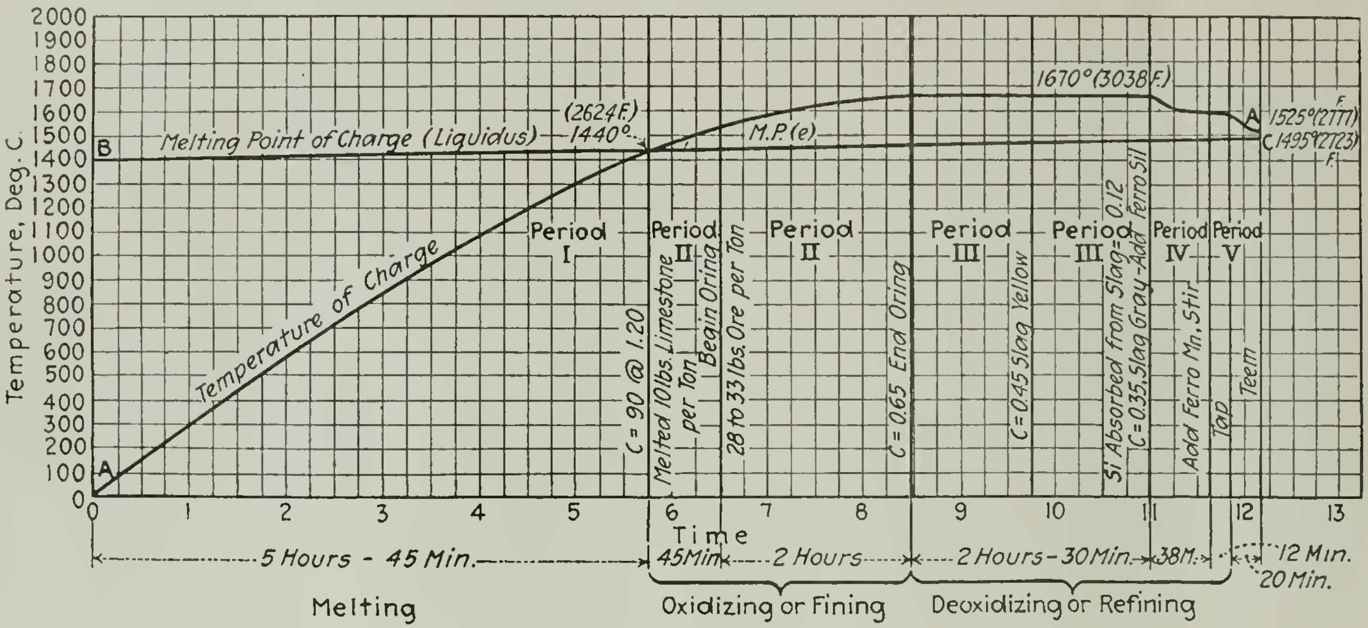

Fig. 1.

We guard against this external cracking:

(a) By tapering the mold so strongly that the ingot frees itself from it readily during the contraction period immediately after pouring, and hence is readily withdrawn.

(b) By pouring at a relatively low temperature and slowly, first so that as the molten steel rises in the mold, the thickness of the already solidified walls may increase fast enough to withstand the increasing ferrostatic pressure, and second, that the size of the columnar crystals and the dendrites may be restrained.

(c) By fluting or otherwise shaping the outer surface of the ingot, which has little power of stretching, so that it can bend horizontally and thus accommodate itself to the resistance of the slower cooling and hence slower contracting interior.

7. *Internal Cracks Including Flakes Must Be Restrained*—(a) By interrupting the relatively rapid cooling in the mold and replacing it with slower cooling in ashes as soon as the ingot has solidified sufficiently to be moved without danger of cracking. When the ingots are cast with the small end up, their molds may be stripped before they have cooled far enough to make it expedient to bury them in ashes. If this is done, the time between stripping and burying them forms a third portion of cooling.

(b) By *saddening*§ and thereby toughening the ingot very carefully, so as to prevent cracking it mechanically in forging or rolling.

(c) By retarding the heating of the ingot for forging and that of the forgings themselves, so as to lessen the thermal stresses.

(d) By as great freedom from inclusions as possible.

8. *Retention of Inclusions Must Be Restrained*—(a) By deoxidizing the molten steel as fully as possible by means of the carbon of the pig iron, because the product of its oxidation is gaseous and escapes, whereas those of all other deoxidizing agents are solid or molten and tend to remain as inclusions. In order that as much as possible of the deoxidation should be done by carbon, the working temperature during refining must be held as high as the safety of the roof will permit.

(b) The nearly complete deoxidation by carbon should be followed by further deoxidation by silicon. The manganese should not be added till after this silicon has done its work of deoxidation, in order that as little as possible of it may oxidize. This is both so that the manganese content of the product may be as nearly constant as possible, and that as little manganese oxide as possible may form to corrode the siliceous hearth of the furnace and form inclusions of manganese silicate with the silica so eaten away. This postponement clearly tends to lessen the oxidation of manganese; first, by shortening its stay in the furnace and, second, by predeoxidizing the bath with the silicon.

(c) The steel should be held in the ladle a moderate length of time to allow the inclusions to rise to the surface, and also for the much more important purpose of permitting the finished steel to fall to the proper temperature for casting into a successful ingot.

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§To *sadden* an ingot means to substitute strong cohesion and toughness for its initial fragility due to its having a very coarse crystalline sugar-like structure. This may be done by giving it a succession of light reductions under a hammer or press, or in a rolling mill. "Sadden" is evidently closely related to "sodden."

9. *Hot and Cool Pouring*—American practice, which is the chief subject of this paper, may be summed up briefly as refining hot but pouring cool. We have now seen four reasons for cool pouring:

1. That it is thought to restrain segregation.
2. That it restrains the size of the dendrites.
3. That it lessens piping.
4. That it lessens or prevents external cracking.

On the other hand, it certainly favors the retention of inclusions, by shortening the time available for their rising to the surface in the ladle. Their opportunity to rise is really good only so long as the steel is completely molten. As soon as it cools to the liquidus, it ceases to be wholly molten and becomes an emulsion of an ever-increasing quantity of pasty particles of metal which have already solidified.

10. *The Furnace Itself Must Be Protected*—To the end,

(a) Its hearth should be protected from iron oxide by covering it, before charging the scrap, with about half of the pig iron used.

(b) The working temperature of the furnace must be maintained during the melting and refining periods at the highest point consistent with safety to the furnace: First, so as to shorten the melting period, during which the hearth is exposed to the attack of the iron oxide, because it is not fully covered by the molten charge; second, so as to stimulate the deoxidizing action of the carbon of the bath during the refining period.

11. *Recapitulation*—There are really only four purposes served by these various precautions, with their many subprecautions, viz.: To make the ingots:

(a) of proper and uniform composition,
(b) of proper macro- and microstructure, and
(c) sound, that is free from pipes, blowholes, cracks, and roughness, and
(d) to prolong the life of the furnace.

12. *General Course of Acid Open Hearth Process*—The foregoing sections teach that the general aim of the process is to melt and decarburize the initial charge; to remove the oxygen incidentally introduced in this decarburization; to bring the charge to a high temperature in order to favor the deoxidation; to push this deoxidation further by means of silicon; and to complete it by means of an addition of manganese sufficient both for this purpose and for leaving in the steel the manganese content required. While doing this last we lower the temperature to that suitable for teeming, taking care that the bath temperature remains so high that the manganese reaction may complete itself, and we then teem the steel into ingots free from inclusions and other mechanical defects. Thus we "refine hot but pour cool."

13. The *raw materials* of the acid open hearth process are pig iron, scrap steel, and in standard American practice a little iron ore.

The ratio of pig to scrap is usually spoken of as if these two materials formed the whole charge. Thus the 40:60 ratio refers to the use of 40 parts, by weight, of pig iron to 60 parts of scrap apart from the small quantity of ore used. This 40:60 ratio is the one assumed in this report.

This pig-scrap ratio varies widely from 100 parts of pig, as in the typical pig-and-ore or Siemens' process, to only about 10 parts as in some European practice. To this important ratio we will return in Sections 33 to 35, after fixing our ideas by considering the standard American practice. Suffice it here to say that, as the functon of the ore is to oxidize the silicon and the excess of carbon over that needed in the product plus that incidentally removed in the necessarily strongly oxidizing process itself, the quantity of ore used increases with the ratio of pig to scrap, from zero in the typical French and Italian non-oring low-pig practice to the large quantity needed for carrying out the typical pig and ore process.

Not more than 10 per cent of the whole charge should be in the form of turnings, lest the rapidity and the indeterminateness with which they oxidize introduce an indeterminate quantity of iron oxide into the charge. Here, as in all other respects, the working conditions should be brought as nearly as possible to a fixed standard, because it is difficult to compensate for the results of even minor variations in procedure.

When pig iron is relatively expensive it may be replaced partly, or even wholly, as a means of introducing the needed carbon, by charcoal, anthracite, or petroleum coke, when these latter may be had sufficiently free from sulphur.

14. *Method of Charging*—Half the pig iron should be spread upon the hearth, the scrap should be placed upon this, and the other half of the pig iron on top of the scrap. The reasons for this arrangement are, first, that the hearth should be protected by a layer of pig iron from being cut by the oxygen-bearing drops of molten scrap. As this molten metal trickles down, drop by drop, over the oxidized surface of the scrap immediately beneath, it is almost certain to become strongly charged with oxide, and hence to corrode the bottom, unless this is prevented by causing it to trickle over a layer of pig iron below it. The carbon and silicon of this pig iron will, of course, react energetically with these drops of molten oxygen bearing iron, to deprive them of their oxygen.

Second, the purpose of covering the scrap with the remainder of the pig iron is to protect it from the cutting effect of the flame, which thus is utilized for oxidizing the carbon and silicon of the pig iron, instead of being employed viciously to oxidize the scrap and, thereby, to cause it to attack the hearth and poison the bath with oxides, as just indicated.

15. *Composition of Charge*—The carbon content of a charge of 40 per cent pig and 60 per cent scrap is about 2 per cent. In melting, this should fall to about 1.25 per cent.

16. *Phosphorus and Sulphur*—For gun steel, the content of these impurities should be as low as possible, hardly over 0.05 per cent of each. In the case of small ingots, less than 26 in. in diameter and weighing less than 15,000 lbs., a very slight increase in the phosphorus and sulphur content might be considered, but not in the case of large ingots, because in these the local concentration of phosphorus and sulphur, both in the axial segregate and in the interdendritic or local segregates, more easily causes a prohibitorily large content of these impurities locally, resulting in black ghost lines.

17. *Manganese*—(a) It is well that there should be from 1 to 1¼ per cent of manganese present in the initial charge. Some of this oxidizes during melting, but an appreciable amount remains in the molten metal and aids both in the removal of sulphur in the form of manganese sulphide and in lessening the oxygenation of the bath. By this latter effect, it lessens the loss of manganese in the final additions.

(b) This restriction of the oxygenation of the bath, even to the end of the process by an initial manganese content as small as 1 per cent. is surprising. The intensity of the deoxidizing conditions needed in making ferromanganese in the blast furnace shows how readily manganese oxidizes; hence we should expect the initial manganese to be oxidized rapidly during the oxidizing stages, both in melting down when the upper half of the pig iron trickles down drop by drop over the oxidized crusts of the metal beneath it in a strongly oxidizing atmosphere, and also in the intentionally oxidizing stage, Period II.

18. *Nickel*—The nickel content of the initial charge should be somewhat less than that required in the final product, so that it may be rectified by addition of nickel at a convenient stage in the process. Rectifying by the subtraction of nickel is, of course, impossible.

19. *Chromium*—Unless chromium is absolutely required by the specifications, it is advised that not more than 0.05 per cent of it should be present in the mixture, because of the difficulty of overcoming its tendency to cause inclusions and consequent laminations. Chrome steels, as such, are not discussed here.

20. *Graphical Representation*—Fig. 1 is an attempt to express the various stages of this process graphically. Vertical distances represent temperature and horizontal time. For convenience, the process may be divided into five periods as follows:

I. Melting the charge.

II. Accelerating the oxidation of the carbon in excess of that needed in the product by oring and raising the temperature to the high point needed for the ensuing deoxidation of the metal.

III. Carrying the deoxidation as far as this can be done by means of the carbon of the bath and high temperature.

IV. Carrying the dexodiation still further by adding ferrosilicon while the bath is still at a high temperature and cooling.

V. Continued cooling, adding ferromanganese, to complete the deoxidation and give the product the desired manganese content, tapping and teeming.

21. *Period I, Melting*—(a) In the first period, the liquidus BC refers to the average melting point of the charge from time to time. The melting point of the scrap is, of course, much above that of the pig iron.

(b) The more strongly curved line AA represents the actual temperature of the metal. Starting completely solid and at room temperature at the origin, it rises gradually during the first period, at the end of which it crosses line BC, so that the actual temperature of the metal coincides with its liquidus, or temperature of complete fusion.

(c) The rise of temperature should be as rapid as possible so as to shorten this period, in the early part of which hearth is attacked more or less seriously by the oxide of the melting metal which trickles down.

22. *Period II, Oring*—(a) When the charge is completely melted it should contain 0.90 to 1.20 per cent carbon. We have now to remove this carbon rapidly. The first step is to add about 10 lbs. of limestone per ton of charge, both that the slag may be fluid and that the limestone per ton of charge, both that the slag may be fluid and that the carbon dioxide given off may start the metal boiling. This boiling should continue from this point on until very near the end of the process, in order to transfer to the lower part of the charge the heat reflected from the roof against the slag floating on the metal. It has often been proved that a "quit bath" may be very heterogeneous in composition. If the circulation is not sufficiently rapid, it should be assisted chemically or mechanically. Mechanical stirring with rods is most beneficial from every point of view.

What may be called "chemical stirring" is that brought about by the evolution of carbon dioxide from the limestone and of carbon-monoxide gas within the bath itself by the reaction between the iron oxide in the slag and in the metal with the carbon of the metal. This reaction is brought about by the introduction of iron ore, or "oring."

(b) In about 45 min. after complete fusion, the charge should be so hot that we may begin oring. The quantity of ore needed is usually 28 to 33 lbs. per ton of charge and is usually added in several portions. A rich pure low-phosphorus Lake Superior hematite may well be used. The ore should not be charged before the metal has passed so far above its liquidus that there is no chance of its being locally so chilled by the ore itself, and by those features of the reaction which are endothermic, that this reaction will not take place actively. Hence the very considerable gap between lines AA and BC when the oring begins.

(c) At about 2 hr. and 45 min. from the beginning of Period II, the carbon should have fallen to about 0.65 per cent. This should bring this period to a close, because the time between the arrival of the carbon at this content (0.65 per cent) and its arrival at the final content (0.35 per cent) is only about enough to insure an approximately thorough removal from the charge of the oxygen which has incidentally been incorporated into it in this second or oring period.

23. *Period III, Deoxidizing or Refining by Carbon*—The object in this period is to carry on the removal of the oxygen from the metal by means of the carbon still present, and of the very high temperature which gives that carbon its needed energetic action on the oxygen. The observations of Doctor Burgess indicate that the temperature of the metal at this time is about 1670 deg. C., which is about as high a temperature as the metal can be brought to without endangering the roof or shortening its life unduly.

24. *Appearance of the Slag*—We have, at present, no direct means of following the removal of the oxygen from the molten metal, nor indeed do we know how much residual oxide is compatible with the needed excellence of the product. Instead we rely on the removal of iron oxide from the slag, on the principle that as the iron-oxide content of the metal falls, that of the slag decreases with it. And, in general, the iron oxide distributes itself between metal and slag in proportions tending to reach an equilibrium, the ratio of which doubtless varies with the temperature, the carbon content of the metal, and other conditions.

Fortunately, the appearance of the slag gives so close an indication of its content of ferrous oxide that the open-hearth process need not be held back to allow a direct chemical determination of that oxide to be made. This appearance may be noted in a slag cake about ¼ in. deep and 3 in. in diameter. But such cakes are seldom made, because sufficient information can be had from the thin layer of slag which adheres to the shank of the test ladle used to secure the many samples of metal required for observation during the process. The outer surface of this slag is dark brown, like that of glazed drain tiles, probably because its ferrous oxide content of the slag decreases. To the layman, it suggests rather an increasing degree of waxiness. But with this understood, we may speak of its vitreousness.

The color of the interior of the slag sample, apart from the rather constant dark brown of the crust, is, next to its vitreousness, the best indication of the large progress of deoxidation. A slag rich in iron oxide, and hence overlying a bath rich in oxygen, is dark brown to black. As the oxygen is removed from the metal and the ferrous oxide from the slag, this color grows continuously paler, to a yellow, a gray, and if the deoxidation is complete in the electric furnace, even to a white.

By the middle of Period III, when the carbon content has fallen to about 0.45 per cent, the ferrous oxide content of the slag should be reduced to about 18 or 20 per cent, and its color should be a clear pale lemon yellow in the case of a charge initially nearly free from manganese; and of a like tint, but more greenish, in the case of a charge containing initially about 1 to 1¼ per cent of manganese, as indeed is very desirable. The manganese oxide adds a strong greenish cast and sometimes a dark greenish central "streak" to the color which the ferrous oxide gives itself. In this case the ⅛ to 3/16 in. thick section of the slag sample has five differently colored layers, two dark brown outer ones, then two of the characteristic yellow, then a central darker cloudy greenish "streak," merging into the yellow ones.

25. *Period III, Continued*—In the remaining half of Period III, the continuing removal of the iron oxide is recognized by the change in the color of the slag from yellow toward gray, in case the charge contains initially 1 to 1¼ per cent of manganese. This color indicates that the ferrous oxide of the slag has been reduced to about 15 per cent, and this in turn that the metal is as thoroughly deoxidized as it can be by the action of its carbon alone. The color and the texture of the slag referred to are typical only of the average practice, and both are affected by the volume of the slag, which depends, first, on the content of silicon and manganese in the charge; second, on the rapidity with which the charge is melted; and third, on the character and composition of the bottom.

During Period III, a certain quantity of silicon is reduced from the slag by the carbon of the metal, which should now have a silicon content of about 0.12 per cent. This increase in the silicon content of the metal, at least up to 0.12 per cent, is recognized by a progressively increasing compactness of the test ingots of the metal and their freedom from gas cavities. This, in turn, is due rather to the decrease of iron oxide in the metal than directly to the increase of silicon content. It has been reported lately that the silicon content of the metal at this point, as determined by chemical analysis, may include an important quantity of silica. One of us has good evidence that, in good practice, the increase of silicon content is not merely apparent but real, and any content of silica is negligibly small.

26. *Period IV, Deoxidizing by Silicon*—(a) A sample of metal is now taken for the "go ahead" test, that is, a test ingot for a combustion determination of the carbon present in the charge. This test should show that the carbon is now about 0.35 per cent, or very close to that aimed at in the final product, so that we may safely go ahead with all preparations for tapping. To insure that the carbon in the product will be very close to that found in the "go ahead" test, we now arrest the decarburization by two distinct steps. First, at the time of drawing this, we make an addition of ferrosilicon, which will be attacked by any oxygen still present in preference to the remaining carbon. After this we decrease the temperature by lowering the damper and shutting off the air and gas, so that the only circulation through the melting chamber is due to leakage. We here act on the principle that the oxidation of the carbon is favored by a high temperature and opposed by a low one, as is well known to be true in the Bessemer process. A visible drop in temperature is shown at once by the changed appearance of the surface of the slag which, by the time the laboratory reports are received, will probably show a few dark cool points.

(b) The ferrosilicon, which may be of the 11 per cent silicon grade, is added while the temperature is still so high that it melts almost immediately and quietly, that it attacks quickly any oxides remaining, and that the resultant silicates coalesce readily, rise to the slag, and leave the bath, which becomes very quiet, and practically ceases bubbling.

(c) The cooling must not go so far as to interfere with the prompt melting of the ferromanganese in Period V, and its reducing any residual oxide. The precaution is easy to carry out successfully.

27. *Period V, Adding Ferromanganese and Tapping*—(a) At the end of about 38 min., Period IV comes to an end, and by this time the ferro-silicon should have completed, as far as it can, the deoxidation of the metal. We now charge the ferromanganese. This addition is purposely delayed until the bath is thoroughly deoxidized, in order to prevent any considerable loss of manganese, primarily in order that the small loss of manganese may testify to the thoroughness of the deoxidation caused by the action of temperature and carbon in Period IV, and secondarily because any considerable loss is likely to be an indeterminate one and thus to lead to irregularities in the composition of the product. Of this manganese, a very small quantity may be consumed in still further reducing the ferrous oxide of the metal, but most of it remains in the metal, giving it the physical qualities called for. At the end of about 12 min., the diffusion of manganese should be so complete that we may tap the charge into a ladle, in which the temperature falls still further, nearly to the liquidus. The steel is held in the ladle long enough, say 20 min. for 60-ton charges which are to be poured into very large ingots, to bring it to the relatively low temperature which is desired in American practice, as explained in Sections 37 and 38. We now teem. This brings us to the end of Period V, and therefore, to the end of the whole operation.

28. *Indications for Period V*—The reduction of the ferrous-oxide content of the slag to 15 per cent or less and the change of its color to gray at tapping time are trustworthy indications that the deoxidizing work of the process has been thoroughly done. In order that this may occur with the normal rate of decarburization, the ferrous-oxide content of the slag should have fallen at least as low as 18 per cent, and it should be yellow, when the carbon content of the metal has fallen to 0.45 per cent. These numbers refer to normal standard conditions, especially as to the weight and composition of the slag, and they may be changed materially by any one of various departures from the normal. For instance, to "run" or melt the roof seriously adds silica to the slag, and by thus diluting its iron oxide lightens its color.

But if the initial charge contains about 1 to 1.25 per cent of manganese, as is to be desired, the resultant manganous oxide of the slag affects these colors decidedly, giving them a greenish tint. Under these conditions, a proper degree of removal of ferrous oxide is indicated if the slag is greenish yellow when the carbon content of the metal has fallen to 0.45 per cent, and greenish gray at tapping time. This greenish yellow slag may contain 15 per cent or less of FeO.

29. *Loss of Manganese on Addition of Ferromanganese*—(a) A further and extremely important indication that the metal has been thoroughly deoxidized before the ferromanganese is added is given by the loss of manganese in this reaction, which should not much exceed 10 per cent of the added manganese. At some well-conducted works, after adding 0.73 per cent. of manganese to a bath containing 0.10 per cent, there is found in the ingots about 0.65 per cent, representing a loss of 0.18 per 100 of steel, or 4.61 per 100 manganese.

(b) Such inferences from the loss of manganese can be trustworthy only when the conditions in general, and in particular the time between adding the ferromanganese and determining the residual manganese, are strictly constant.

(c) If a larger proportion of the added manganese is lost, taking into account the length of time between adding ferromanganese and teeming, it is good evidence that the ferrous oxide had not been thoroughly removed from the steel. It is recommended that this point be watched with great care.

30. *Reasons for Procedure in Deoxidizing Bath of Molten Steel*—(a) At the end of the oring, Period II, the bath of molten steel is richly charged with oxygen, probably in the form of ferrous oxide FeO. and the next task is to remove this oxygen as completely as possible. This means transferring the oxygen from the ferrous oxide to one or another agent. such as carbon, silicon, and manganese, each of which in its turn becomes oxidized. The procedure should be such as to cause as much of this oxygen to be removed by carbon and as little as possible by silicon and manganese, because the oxide of carbon is gaseous and escapes spontaneously, whereas those of silicon and manganese are molten. They are liable to remain entangled in the solid metal in the form of inclusions, which weaken and embrittle it greatly.

(b) In order that as much as possible of the oxygen should be removed by the carbon, it is necessary to work at as high a temperature as possible, because the power of the carbon to combine with the oxygen increases with the temperature. Hence the temperature of the metal is raised as rapidly and as high as is consistent with safety to the roof of the furnace.

(c) As the quantity of iron oxide remaining in the bath decreases, the carbon of the bath, finding itself no longer fully occupied in deoxidizing iron oxide, attacks the silica of the slag and hearth, introducing silicon into the molten metal. By the time that this action has raised the silicon in the bath to about 0.12 per cent, the power of the carbon to remove further oxygen has become so far exhausted that the further deoxidation of the dissolved iron oxide by this carbon has become so slow that it becomes expedient to use a stronger deoxidizing agent. Our choice naturally lies between manganese and silicon.

(d) In the acid open hearth process, to which this paper refers, silicon should be used here, chiefly because the silica which it forms does not attack the hearth of the furnace as the manganous oxide resulting from the use of manganese does, forming manganese silicate.

It is true that, in careless hands, the use of silicon may cause the formation of very harmful inclusions of silica, but if the care and skill appropriate to the manufacture of cannon steel are used we believe that this danger can be avoided fully. Of course whatever deoxidizing agent we use we must provide for the removal of its oxidized products. In the case of carbon, these products escape spontaneously because they are gaseous. In the case of manganese, they escape readily because the resultant silicates of manganese are fusible over a wide range of composition, so that they coalesce easily into masses so large that they rise quickly to the surface by gravity. But the product of the oxidation of silicon, silica, is infusible by itself at the open hearth temperature. Hence should any of it remain uncombined with metallic oxides its individual particles would stay suspended as a fine emulsion and, persisting in the finished product, injure it greatly. Hence the use of silicon presupposes the presence of enough oxide of iron or manganese to form with the resultant silica a fusible and hence a coalescing product, which will remove itself freely by gravity. This is in harmony with the general procedure, using silicon for nearly but not quite the last of the deoxidation, when the resultant silica finds residual oxides to combine with, and then completing the deoxidation with manganese, the products of the oxidation of which are fusible and hence self-removing.

(e) Moreover the quantity of silica resulting from the removal of one part of oxygen from the molten metal by silicon is clearly far less than the quantity of manganese silicate resulting, first, from the oxidation of manganese to manganese oxide by that oxygen, and, second, from the formation of manganese silicate by the scouring action of the manganous oxide on the hearth.*

That manganese silicate does form, if manganese instead of silicon is added at this stage, has been proved directly by dissolving quantities of the resultant metal large enough to yield enough inclusions for chemical analysis.

(f) A welcome effect of the silicon added at this stage, when the oxygen content of the bath has become so low, is that it practically arrests the oxidation of the carbon, probably by combining by preference with that oxygen. Indeed, we now have the appearance of complete equilibruim, with no further transfer of any of the elements present from metal to slag. This arrest of the progressive oxidation of the carbon, manganese, and silicon simplifies the conduct of the process by assuring us that the content of these elements found in the "go ahead" test will persist and occur in the ingots, practically undiminished in the case of carbon, and but slightly diminished in that of manganese.

(g) Parenthetically, in operating on a basic hearth, whether that of a basic open hearth furnace, or that of a basic electric furnace, reasoning the converse of that in Section 30 (d) and (e) leads us to use manganese instead of silicon for removing the bulk of the oxygen left at the end of Period III, when the carbon has done its work of deoxidation as thoroughly as it can. The removal by silicon of the oxygen left at this stage would yield silica, which would attack the basic hearth, corroding it and thereby yielding inclusions of silicate of lime, magnesia, or whatever bases constitute the hearth. As before, the quantity of these inclusions of silica plus base, resulting from the removal by silicon of a given quantity of oxygen from the metal, would exceed the quantity of manganous oxide formed in performing that same deoxidation by means of manganese.[†] Attention should be called to recent practice where ferrosilicon is used as a preliminary addition in basic steel melting both in open hearth and in electric furnaces with basic hearths.

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*One part of oxygen would yield by the reaction $2O + Si = SiO_2$ $(2 \times 6 + 28.4) \div 2 \times 16 = 1.9$ parts of silica; whereas the reaction $O + Mn + SiO_2 = MnSiO_3$, it would yield $(55 + 28.4 + 3 \times 16) \div 16 = 8.2$ parts of manganese silicate if of that composition, or about four times as much. Indeed the difference in favor of silicon is likely to be still greater, because each molecule of manganous oxide being released in the presence of an unlimited excess of the silica of the hearth, is likely to combine with more than one molecule of that silica.

(h) Returning to the study of the acid open-hearth process, manganese in the form of ferromanganese is now added and stirred in, both to push still further the removal of oxygen from the bath and to give the metal the intended manganese content.

(i) Looking back on this deoxidation as a whole, we note first that carbon is the most desirable deoxidizing agent, because its oxides are gaseous and cannot form inclusions; second, that silicon is next in merit in acid furnaces, because it leaves less inclusions than manganese; and third, manganese is the last addition to make in such furnaces, because it is the strongest and can remove most of the remaining oxygen.

(j) Accordingly, by maintaining a very high temperature we enable the carbon to do as much as possible the work of deoxidizing. We then use silicon to do as much of the remaining deoxidation as it will; and only then do we add manganese to complete the little deoxidation still to be done, and to give the product the needed manganese content.

(k) It is interesting that the manganese silicate formed on adding ferromanganese to imperfectly deoxidized steel is more abundant in the deeper seated parts of the ingot, especially of large ones, than in the crust, probably because of the fusibility of the manganese silicate itself. In short, this silicate migrates like the segregating elements, carbon, phosphorus, and sulphur. In such steel, an excessive quantity of this silicate forms, because the abnormal quantity of oxygen present in the bath oxidizes a correspondingly great quantity of manganese to manganese oxide, which in turn dissolves from the hearth a correspondingly great quantity of silica.

This concentration of the manganese silicate in the deep-seated, and therefore last solidifying, parts may be referred jointly to segregation proper, and to the greater length of time available there for the coalescence of the manganese silicate, under the churning action of the convection currents in this imperfectly deoxidized, and hence wild, steel, into particles large enough for detection. This coalescence, though it would not affect the quantity of the manganese silicate found by chemical analysis, would increase that detected by the microscope.

31. The *use of aluminum, titanium, vanadium,* and like deoxidizers for the specific purpose of removing the last of the oxygen from the bath, as distinguished from their legitimate and growing use for introducing some of these elements as essential constituents of an alloy steel, should be discouraged. It affords so easy a way of covering up imperfect deoxidation in the normal way, chiefly by carbon, then by silicon, and last by manganese, as to form a constant temptation to slovenly working, and especially to slighting the thorough deoxidation by carbon at a prolonged high temperature. The oxide products of deoxidation by these elements are not gaseous, and hence tend to form inclusions. We do not discuss the manufacture of alloy steels other than nickel steel.

32. *Continental Low Pig Process*—Instead of using about 40 per cent of pig iron, as in the American practice just described in Sections 7 to 20, and thus having in the bath when first melted far more carbon than is needed in the product, then removing this excess of carbon with ore, and then removing the oxygen introduced by this ore, the typical French and Italian practice is to use much less pig iron, sometimes so little that the charge when first melted has only about 0.10 to 0.20 per cent more carbon than is needed in the product. In this practice, the use of ore is avoided altogether, because the slight excess of carbon present will be removed spontaneously in bringing the charge to tapping temperature, by the action of the furnace atmosphere and of the iron oxide which is taken up during melting, and distributes itself between metal and slag in proportions approaching equilibrium. Thus here, quite as in American practice, metal and slag contain iron oxide which has to be removed. Part of this removal is done by such excess of carbon as there is, but if this excess is very small, it has to be helped out by adding pig iron in some works, coke in others, and both in still others.

The pig iron is added when the carbon has fallen to about that sought in the product, and the work of deoxidation then proceeds by means of the carbon and silicon thus introduced. In some works, a second and even a third lot of pig iron is added when the carbon content again falls to the point sought.

Coke, when added, rests on the slag, and deoxidizes it directly. In some works, the slag is given a predetermined composition favoring its deoxidation, and through this the deoxidation of the metal, by additions of lime and limestone, clay, sand, and fluorspar to give fluidity.

These steps should enable us to make use of coke as an additional and very energetic remover of iron oxide. For instance, in some French works, the coke treatment is continued not only until the slag is green, but until the iron oxide has been so far removed from the metal that it hardly reacts at all on the carbon, and hence the bath is completely quiet. Even after this, the charge is held for 1 hr. at a very high temperature to allow the inclusions to rise, and the removal of the iron oxide to progress still further.

33. *Advantages and Disadvantages of Oring*—(a) Now that we have examined at length, Sections 7 to 20, the standard American high pig or oring practice, and have glanced, Section 32, at the Continental low pig or oreless practice, let us here bring together on one hand the advantages of oring, that it enables us to use a large proportion of the sometimes cheaper source of iron, pig iron; that it facilitates the process, by means of the boil which it induces; and that it increases the yield; and on the other hand its advantages of introducing into the molten bath iron oxide which must needs be thoroughly removed. Here, too, we should look at the advantage of high pig practice, that in it the slag color is a more trustworthy indication of the condition of the metal; and at its disadvantages, that in it there is a thicker blanket of slag interposed between what might be called the two working surfaces, that of the metal and that of the slag

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[†] One part of oxygen removed by the reaction $O + Mn = MnO$ would yield $(55 + 16) \div 16 = 4.4$ parts of manganese oxide, whereas if removed by the reaction $2O + Si + 3CaO = Ca_3SiO_5$ it would yield $(3 \times 40.1 + 28.4 + 5 \times 16) \div 2 \times 16 = 7$ parts of lime silicate if of that composition.

The numbers of course have no claim to precision. They are based on the assumption that tricalcic silicate results, with nearly three parts of lime to one of silica, which agrees with H. H. Campbell's analysis of basic open hearth slag. ("Manufacture and Properties of Iron and Steel," 205. 1907.)

itself, and that it works more slowly than low pig practice.

(b) It is self-evident both that oring enables us to increase the ratio of pig to scrap and that this, in and by itself, is desirable if pig iron is cheaper than scrap. In arriving at their true relative cost, we may be influenced by the existence or lack of a supply of molten pig to pour into the open hearth, by the slower working in high pig practice, and by like considerations. In American open hearth works it is rare that pig is enough cheaper than scrap to make it truly economical to use appreciably more than the 40:60 ratio, which we have advised for steel of this carbon content.

(c) A second merit of oring, and the high pig practice in which it is used, is that the oxygen of the ore, in oxidizing the excess of carbon of the charge, keeps the charge in rapid ebullition, and thus simplifies the melter's difficult task of keeping his roof within the narrow range of temperature between that needed to heat the charge hot enough through and through, and the only slightly higher temperature which would destroy the roof.

The boiling carries down into the metal and through it the heat reflected upon the upper surface of the slag from the flame and the roof, thus both heating the metal and cooling the roof. If the bath is still, this heat is in large part reflected back from the slag to the roof.

Because the difficulty of this transfer of heat from roof and flame to metal increases with the thickness of the slag layer, the boil is especially needed when there is much slag; that is, in high pig practice, in which the silica from the ore and from the oxidation of the silicon of the pig implies a correspondingly great quantity of slag. This consideration cautions us not to claim undue weight for the boil as an advantage of the high pig oring practice, remembering the obvious reply that it is this practice itself that gives the boil its importance, both for transferring the heat into the metal and for making the metal effectively accessible to chemical treatment applied to the upper surface of the slag.

(d) The oxygen of the ore, in oxidizing the carbon and silicon of the pig iron, leaves the iron with which it is initially united, by such reactions as $Fe_3O_4 + 4C = 3Fe + 4CO$. Part of the iron so left adds itself to the molten bath and so increases the yield of iron. In making fine steel, this saving is rarely of great moment in comparison with the feature of the practice which influence the quality.

(e) Turning from the merits to the disadvantages of the high pig or oring practice, the thicker blanket of slag which it implies, as shown in bath, so essential to high quality; for the oxygen strives ever to distribute itself between metal and slag in a ratio, fixed for given conditions even though varying with the conditions, so that the metal can be deoxidized only as the slag is.

Moreover, this equilibrium ratio is not between the total quantity of oxygen in metal and slag, respectively, but between the percentage of oxygen in each, so that the percentage to which the iron oxide of the slag must be lowered in order to bring about a given thoroughness of deoxidation of the metal is independent of the quantity of slag. Hence, the more slag there is the greater is the work of deoxidizing it thoroughly enough to induce a given thoroughness of deoxidation of the metal. It may be that the thoroughness regularly attainable is inversely as the quantity of the slag, a small quantity being susceptible of more thorough deoxidation than a large one.

(f) The objection which is urged strongly against oring, that which seems to have led to its exclusion from the standard French and Italian practice, is that, by introducing oxygen into the molten metal, it increases the difficulty of thorough deoxidation, and indeed lessens the practicable thoroughness of deoxidation of the metal.

These two objections (e) and (f) may well be taken together, as two aspects of a single objection. Their validity is not self-evident. To deoxidize a greater quantity of slag as thoroughly as a smaller one should indeed take longer, but it does not follow that the practicably attainable thoroughness of deoxidation is less with the larger quantity. Again, in purification of any kind, whether by washing or deoxidation, it is the last stage, the final degree of thoroughness, that calls for the technical skill. The greater the needed thoroughness of deoxidation, the stronger must be the deoxidizing conditions.

But while the validity of these objections is not self-evident, neither is their invalidity. Rather than belittle or ignore them we should diligently seek evidence as to their true weight. Such evidence should be found in the iron-oxide content of the slag, and the physical properties of the steel, in oring and in oreless practice respectively, though in this comparison it is hard to make the oring the sole variable.

The thorough purification of the metal from oxygen, both that formed in melting and any introduced as ore, needs indeed our most careful attention, as is shown by the length at which we describe it in Sections 23 to 30.

34. *Appearance of Slag in Oring and Oreless Practice*—American metallurgists have found a serious objection to low pig practice in the diminished trustworthiness of the appearance of the slag as a guide to the thoroughness of the deoxidation of the metal. The reason for this is evident. In the American practice, it is the metal itself that, through its carbon and silicon, initiates the removal of ferrous oxide. These deoxidize the ferrous oxide in the metal and thereby induce a corresponding removal of ferrous oxide from slag to metal, following the principle that this oxide always tends to distribute itself between slag and metal in an attempt to approach equilibrium. Hence the removal of iron oxide from the metal here precedes its removal from the slag, and hence a certain degree of removal of this oxide from the slag, as indicated by its color, is trustworthy evidence that the corresponding removal from the metal has already taken place.

But when we proceed by adding coke, or other form of carbon to the slag, it is in the slag that the removal of iron oxide is initiated. Only after the coke has begun removing this oxide from the slag does the iron oxide in the metal rise into the slag to replace, in part, that which the slag has just lost, in the attempt to approach an equilibrium distribution of the oxide between slag and metal. Here, then, the removal of iron oxide from the slag precedes that from the metal and may precede it materially. Thus a given thoroughness of removal of iron oxide of the slag is not such good evidence that the corresponding removal from the metal has already occurred.

A natural answer may be that a suitable time allowance should be made for this lagging of the metal behind the slag in its loss of iron oxide, and that a fuller removal of this oxide from the slag should be required when, in coke practice, the removal is initiated in the slag than in the American practice in which it is initiated in the metal.

To be accurate, even in coke practice, while the coke is initiating this removal in the slag, the carbon of the metal is also carrying it on there.

35. *Summary of Advantages and Disadvantages*—We aim rather to expose than impose practice. Now that we have seen the advantages and disadvantages of these two practices, the oring and the oreless, we may well remember that excellent as the results of our American fine-steel practice are, it has evolved under the American high pig traditions, and that there has been no fair chance to compare exhaustively and conclusively the features in which those two practices differ This is as true of the temperature differences as of those of oring. Such a comparison should be to the interest of all concerned, the public included. Each operator will reach the best results with the practice to which he is accustomed, but this does not indicate that he might not get still better results with some modification of his practice, once he is well accustomed to it.

The following numbers may serve as a nucleus for the data needed for such a comparison as we have just referred to. The physical properties called for in the first line are those required by the specifications of the United States Government for gun steel, whereas, if we are advised correctly, those of the second line are specified by some foreign governments.

American and One Foreign Specification for Cannon Steel

	Tensile strength, lb. per sq. in.	Elastic limit, lb. per sq. in.	Elongation in 2 in., per cent	Contraction of area, per cent
American . . .	95,000	65,000	13	30
Foreign	92,000	57,000	14	not specified

We further understand that where an elastic limit as low as 52,800 lbs. to the square inch is accepted, provided the contraction of area is at least 26/4 per cent, the foreign practice also makes use of the impact test, but we believe that the test prescribed would not in fact reject any metal which passes the American specifications. Recently wide experimentation has been made in impact tests in addition to the foregoing, and much new light has been obtained.

Teeming, Molds, Etc.

36. *The Ladle*—A good deal of metal rich in inclusions is likely to accumulate on the very bottom of the ladle and particularly about the stopper, because the relatively cool ladle bottom cools the steel first tapped upon it, and thus thickens it, and impedes the rising of the inclusions which it contains. Therefore, the first 300 or 400 lbs. of steel which run through on raising the stopper should be poured into an old mold set

MEETING OF STEEL MANUFACTURERS.

The annual meeting of The Association of American Steel Manufacturers was held at the William Penn Hotel, Pittsburgh, Pa., February 17. This Association, which now comprises thirty-nine of the largest steel and iron manufacturing companies and corporations, was organized in 1895. It is not a trade or commercial organization but has devoted its activities to the discussion of technical questions in connection with rolling mill practices and with specifications for and inspection of steel and wrought iron products; and the cooperation with other associations and societies on such subjects, with a view to the adoption of standards of mutual benefit to the consumer and producer.

Mr. Charles L. Taylor, widely known in the steel trade, whose death occurred February 3, acted as secretary at the organization meeting of the Association and for a number of years took a keen interest in its affairs. Mr. W. A. Bostwick, who at his death February 4 was president of the International Nickel Company, was president of the Association from 1907 to 1911.

It is a coincidence that representatives of Jones & Laughlin Steel Company and Central Iron & Steel Company were president and vice president of the Association the first two years of its existence and during the past two years. Mr. Willis L. King of Jones & Laughlin Steel Company, and Mr. G. M. McCauley of Central Iron & Steel Company, were the first president, respectively. During the past two years Mr. Robert H. Irons, President of Central Iron & Steel Company, and Mr. Jesse J. Shuman, Inspecting Engineer of Jones & Laughlin Steel Company, have been president and vice president, respectively, of the Association.

The following officers were elected at the annual meeting: President, Jesse J. Shuman, Inspecting Engineer, Jones & Laughlin Steel Company; Vice President, E. F. Kenney, Metallurgical Engineer, Midvale Steel & Ordnance Company; Secretary-Treasurer, J. O. Leech, Manager Bureau of Inspection and Tests, Carnegie Steel Company.

Mr. Irons was presented with a silver after-dinner coffee service in appreciation of his services for the past two years.

MEETING OF ELECTRIC STEEL FOUNDERS' RESEARCH GROUP.

Officers and operating representatives of the Electric Steel Founders' Research Group held their last regular meeting in Milwaukee on February 6, 7 and 8. This Group was formed about two years ago for the systematic prosecution of cooperative technical work which could be directly applied in improving the manufacture of steel castings.

The idea back of this cooperation originated from the realization that the technical experts who are usually found directing the operating departments of steel foundries are prevented by immediate attention required for the disposition of routine matters, from concentrating on the investigations which could be prosecuted more effectively if they would engage the exclusive attention of one individual and if he would coordinate the technical activities of a few plants whose processes and products place the companies in the same class.

The members of the Group are the Electric Steel Co., Chicago, the Ft. Pitt Steel Casting Co., McKeesport, Pa.; the Lebanon Steel Foundry, Lebanon, Pa.; the Michigan Steel Casting Co., Detroit, and the Sivyer Steel Casting Co., Milwaukee. The Group's headquarters are at 639 Diversey Parkway, Chicago, where Major R. A. Bull, Research Director of the organization, maintains his office.

At the Milwaukee meeting reports were made by the operating heads of plants on comprehensive investigations into important foundry problems that had been delegated by the Group to the several companies. It is stated that much progress is being made through these Group investigations and that prospects for future accomplishments are most encouraging. The Group researches which were reported in detail at the Milwaukee meeting included those on the subjects of annealing, core practice, facing sands, furnace practice and pouring practice.

Arrangement of Open Hearths in Germany

The Steel-Makers of Germany Have Not Adopted Water Cooled Parts, But Use Detachable Posts—Arrangement of Gas and Air Chambers Is of Special Interest.

By HUBERT HERMANNS

BEFORE the war, the development of the Siemens-Martin process was based on sound principles. This was partly due to the demand for material with better mechanical and chemical properties than can be obtained by the Thomas process and partly to the demand for cast steel. On the other hand, the production of open hearth steel was limited to a certain extent by the cost, which was higher than that for Thomas iron. As long as the furnaces were charged with liquid material, the cost of production was about the same for both processes, and was not influenced materially by market conditions. But these conditions were different for open hearth operations, when pig iron and scrap had to be bought outside The difference in price for these materials, varying considerably according to market conditions, had a large influence upon the cost of production in these cases and caused the operators to watch carefully operation and production.

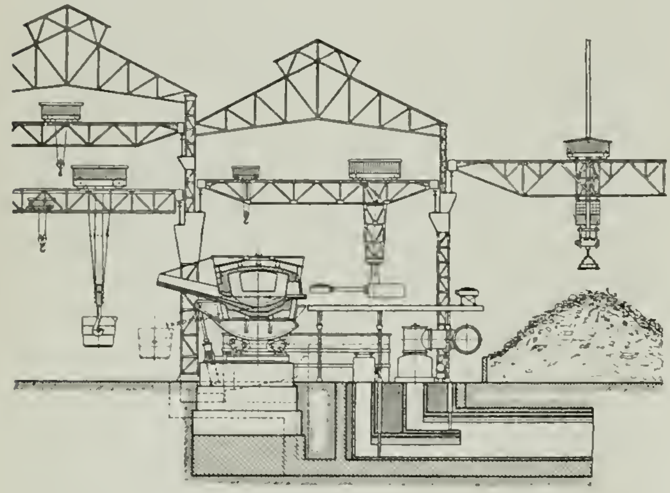


Fig. 1.

It is only natural that the, so to say, one sided requirements of the war caused a certain dislocation of the available raw materials and also a change in the quantity and quality of the finished open hearth Thomas products; the production of Thomas wrought iron had to be curtailed in the interest of the open hearth steel, because the operating forces and the raw materials had to be used as much as possible for the production of quality war material.

The Thomas process, prevailing in Germany, was based partly on the large Minette ore deposits in Lothringen and Luxemburg, and partly on the imported ores with a high percentage of phosphores or on the pig iron, made from such ore. The basic open hearth process is based chemically on the same kind of ore, but its operation is entirely different as far as working conditions are concerned. Leaving aside the consideration in regard to coal consumption, such as is necessary for the converters for driving the blowing engines and other auxiliaries and for the gas producers, the open hearth furnace has the advantage that the otherwise valueless scrap can be used, thus enabling the operator to work his furnace as economically as possible.

, A decrease in the cost of production, however, can only be obtained by a highly developed design of the layout of the furnace and a most favorably developed use of the raw material. Under highly developed design of the layout of the furnace is understood not only the layout of the furnace proper, but also the best possible arrangement of the cranes, and all other auxiliaries which are necessary for an efficient working of the furnace and which are used to eliminate the human element as much as possible.

Experience has taught a general principle in regard to the layout of open hearth plants, deviations from which should only be made when local conditions demand them. Certain rules have been laid down and have been found satisfactory and which should be adhered to whenever possible. This holds good mainly for the regenerating chambers.

It was a greatly discussed question how these chambers could best be located to suit conditions. At present this question has been solved in such a respect that the chambers are arranged outside of the furnace proper. However, this arrangement requires more space and a higher first cost. The advantages obtained with such an arrangement are, first, more space on the charging and operating floor and, second, the impossibility of the slag entering the checker chambers and thus clogging them up. Slag pockets can easily be arranged, which collect the slag before it enters them.

The general description of a modern open hearth furnace is as follows: In order to strengthen the walls they are built outside in a curved form, through which arrangement sharp edges and corners are avoided. The stays and anchors of the chambers should be designed as simply as possible and the brickwork should be easily accessible. It is for this reason not a good policy to cover the outside of the chambers with a steel cover, although this is of advantage in so far as it protects the brickwork. The big disadvantage, however, connected with it is due to the fact that it is practically impossible to make repairs on the brickwork without tearing a part of the whole jacket down.

The arrangement of the charging and discharging machinery is the same as in general use in America. This arrangement has the advantage of keeping the floors clear of obstructions and allows the charging crane to pick up the charging troughs not only on the long side of the building, but also on the short sides. With such an arrangement it is well to have the ladle crane independent of the other traveling cranes in order not to interfere with the working of the crane. All other traveling cranes should be located above the ladle crane.

Fig. 1 shows a layout of an open hearth plant which has been designed with the intention of reducing operating costs to a minimum. The plant comprises five tilting furnaces, each 38 ft. 4 in. long and 14 ft. 2 in. wide, with a capacity of 50 tons each.

It is true tilting furnaces require higher first cost, but they permit a larger tonnage and are for this reason used more extensively from year to year. The main advantage of a tilting furnace will become apparent when charging liquid material, because the same spout is used for charging and for casting. This simplifies materially the construction of the furnace and reduces the operating force.

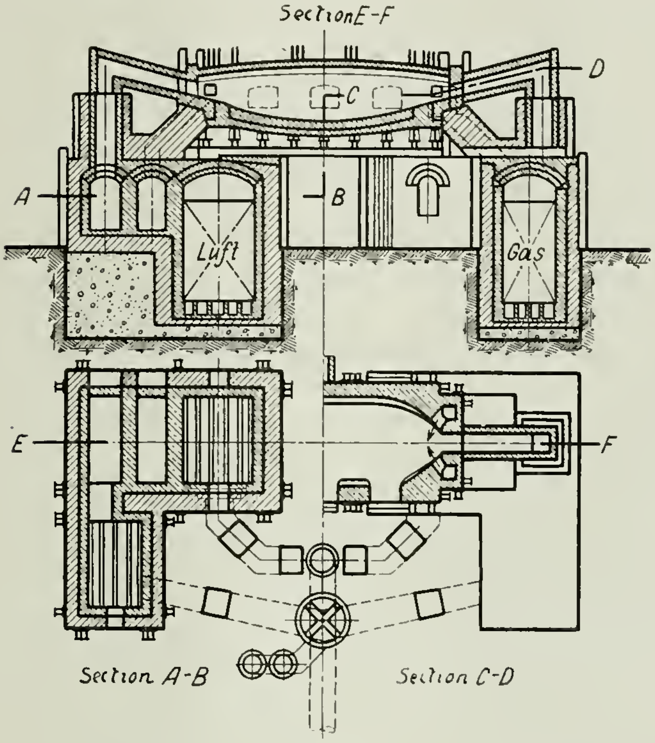


Fig. 2.

The arrangement of the charging and other traveling cranes is made in such a way that there is no machinery required on the hall floor in the front or the back of the furnaces. The scrap is taken from the railroad cars by means of magnetic cranes either to a storage place or directly to the charging molds. These charging molds are taken up by the charging cranes, swung around and emptied into the furnace. In this way all manual labor, as far as hauling the scrap proper is concerned, is eliminated. For the operation of the cranes four operators are required.

The liquid steel is taken by means of two ladle cranes and cast in four casting pits. The tilting of the ladle is done by means of a second traveler, which runs on the lower truss of the ladle crane. Another additional crane is located above the ladle crane and is operating on a higher track.

In the following a few details of modern open hearth furnaces may be shown. In the United States, water cooled parts are largely used in order to prevent the burning out of those parts of the furnace. This arrangement has not met with favor in Germany on account of the large amount of cooling water required. Here detachable posts are used, which have been found to work satisfactorily and efficiently. They allow a quick change and replacement of the burned out parts, thus saving considerable time in shutting down the furnace. With this arrangement it is not necessary to cool the whole furnace, but only the gas duct. It also allows for the building up of spare ducts, which when necessary can be installed on short notice in place of the old ones.

A furnace with detachable posts is shown in Fig. 2. The detachable parts of the uptakes and posts are entirely independent from the rest of the furnace masonry. These parts rest on the one side on the brickwork above the slag pockets, on the other side they rest against the head of the furnace. The joint between head and ports is filled with fire clay and thus made tight in a very simple manner. The whole brickwork is held together with an iron frame with hooks which allow the ports to be hauled easily with a crane. This arrangement furthermore allows a better access to the air uptakes and does away with unnecessary brickwork around those places.

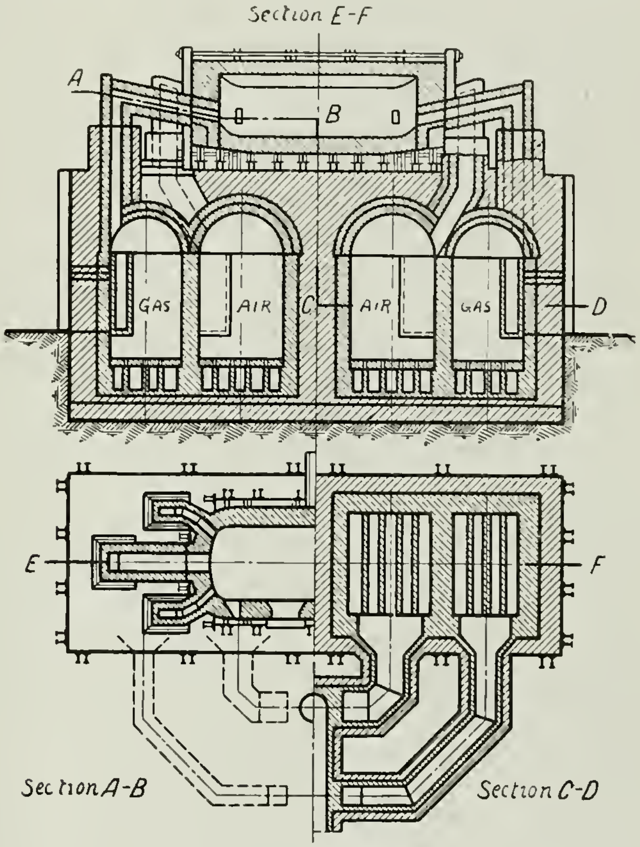


Fig. 3.

The arrangement of the gas and air chambers is of special interest. In most cases gas and air chambers are combined either directly under the furnace or outside of it. With the arrangement, shown in Fig. 2, only the gas chambers are located outside the furnace, whereas the air chambers are below it. This makes both kinds of chambers easier accessible. The slag pockets can be located behind the gas chambers below the furnace. This layout is especially advantageous in cases where for lack of space it is impossible to locate both chambers outside the furnace. The valves and the operating mechanism can be put between the two gas chambers in a way similar to the used when both chambers are outside. Another advantage is the smaller cost for the gas ducts. All this shows that the arrangement, Fig. 3, deserves the attention of the furnace designer, because it may, under certain circumstances, reduce first cost and operating cost, thus guaranteeing most satisfactory operating conditions.

As long as the furnaces are of the ordinary square shape, it is very difficult to exchange the detachable posts on account of the anchorage of the furnace. This difficulty is avoided when the furnace heads are built round, using for anchorage a sheet steel cover, which can easily be attached. This arrangement has, besides the possibility of changing the ports, a number of other advantages. The walls of the upper part of the furnace can be built of uniform thickness, thus avoiding on the one hand protruding edges in the inside of the furnace, which are easily molten away, and on the other hand too thick walls, which means a waste of refractory material. At the same time the arrangement allows an easy cooling of the furnace heads by the surrounding air, which prolongs the life of the furnace.

Fig. 3 illustrates a furnace with round head. The gas uptake is made detachable in the regular way in the center line of the furnace, whereas the two air uptakes come in from the side and are also made detachable. As conditions may require, any one of the uptakes may be taken out on short notice and in a very short time, and can be replaced at once by a new one, prepared beforehand for the purpose.

Recently in many cases not only producer gas, but also coke oven gas and other high grade gases are used in the steel plants. In order to be able to use all the high grade coke oven gas, having a heating value of about 750 Btu. cu. ft. instead of using part of it in the coke oven the latter are fired with a low grade producer gas with a heating value of about 140 Btu. cu. ft. Where possible even blast furnace gas of about 100 Btu. cu. ft. can be applied instead of the producer gas.

The hydrocarbons contained in coke oven gas are decomposed at higher temperatures; they, therefore, would clog up the channels in the regenerating chambers, thus putting them out of commission in a short time. For this reason the furnaces for coke oven gas are not provided with gas chambers, but have air chambers only. This means larger air chambers in order to permit a good regulation of the temperature and to use all the waste heat. The total quantity of waste heat travels through the air chambers only. Such a furnace, when built correctly, permits the use of cold gas containing high value hydrocarbons, with the best utilization of the waste heat.

Discussion of Forge Furnaces

A Brief Practical Review of the Various Types of Forge Furnaces, Pointing Out Possibilities for Saving and Increased Efficiency with Various Classes of Fuel—Regeneration and Recuperation.

By CHARLES LONGENECKER

UNDER the heading Forge Furnaces the following types may be considered:

1st. Soaking pits.

2nd. Regenerative type furnaces — large hearth area.

3rd. Non-regenerative type furnaces—large hearth area.

4th. Furnaces of small hearth area.

The applicability of soaking pits for forging furnaces may be questioned by some but there are plants equipped with these furnaces. In some ways the soaking pit is an ideal furnace for heating steel for forging which feature will be considered more fully.

Many different modifications of the above classification can be mentioned. The first, second and third types may be equipped with waste heat boilers and the fourth type might be constructed with regenerators but such modifications would not change the type, simply modify it. The fourth type includes those furnaces heating steel for drop forging purposes and other comparatively light hammer operations. Recuperation has been applied to types three and four.

Soaking Pits.

This type of furnace is used in comparatively few plants as it is only applicable for heating ingots. At times it may be employed for a "second heat" but this is problematical. Plants having their own open hearth furnaces can install soaking pits to advantage if the tonnage is enough to justify the expenditure and if the furnaces can be kept in continuous service. The economic value of "soaking pits" is dependent on uninterrupted operation and heavy tonnage and hence these pits are not applicable to any but the largest forge plants where heavy ingots are handled. The building housing these furnaces must be constructed with regard to the work to be performed and adequate height allowed.

The fuel consumption will vary according to the temperature at which the ingots are charged. If they are charged hot as received directly from the open hearth, immediately after stripping, the fuel consumed will be exceedingly small. In fact, when the ingots are charged very hot, the "soaking pit," as the name implies, affords the opportunity for the initial heat contained in the steel, as received, to equalize. In this case no extraneous heat need be applied. This, indeed, was the original conception of the "soaking pit" as exemplified by the Djer's pit. In this form of the pit no provision was made for heating other than the heat provided by the ingots themselves. Today the same principle, somewhat modified, is practiced in the "fireless cooker." In the latter case the heat is imparted to the foods to be cooked by another object which has been heated. This source of heat radiates and the heat is confined and absorbed. No heat is allowed to leave the enclosure in either the "soaking pit" or the "fireless cooker" except that portion which defies retention.

When the ingots are charged hot into "soaking pits" the flow of heat in the piece (ingot in this case) is directly opposite to that which takes place in any other type of furnace charged with cold steel. In the latter form of furnace, heat is applied to the outer surface of the piece and this heat must penetrate to the centre. The flow is reversed with a hot ingot in the soaking pit. Here the molten centre must give up its heat to the surrounding metal. As to the question of segregation, piping, etc., it will be apparent that heating from the centre to circumference is an ideal method. Fissures and stresses are not so liable to form and sharp corners are not apt to be overheated as in a reheating furnace.

When cold ingots are charged the conditions there are similar to any other type of furnace as regards flow of heat. One other point of value possessed by the soaking pit is that hot ingots can be brought direct from the open hearth and placed in the pit with no danger of the ingot "bleeding" as it would do if placed in a horizontal position with the centre molten.

The fuel consumption on cold ingots varies within wide limits depending on the size ingots, etc. It may run from 300 to 500 lbs. per ton of ingots heated. With hot ingots as noted very little heat is required depending on the temperature of ingots as charged and length of time they are held in the pits.

With natural gas, oil, and powdered coal the air only is preheated while with producer gas both it and the air will be heated.

Regenerative Forge Furnaces.

This type of furnace is usually of large dimensions and consequently heats ingots or large blooms. Regeneration is applicable where the heat volume of the waste gases is large and at high temperature. There is a great divergence of opinion concerning the economy of regeneration in forge furnaces. The final analysis will disclose in every case whether the saving in fuel, and attending economies, will counterbalance the additional cost for equipment to effect regeneration. The size of the furnace practically determines what should be done. Where the tonnage to be heated is considerable and the furnace operation continuous, regeneration should be employed. The problem of regeneration is capable of solving without entering the realm of chance. Knowing the quantity of material to be heated the fuel consumption can be closely approximated from experience. With this knowledge the heat carried off by the waste gases can be determined and likewise the quantity of air required to burn the fuel. The efficiency of heat exchange is known for most forms of regenerators so that there remains only a calculation to determine the heat returnable by the air. The saving will be shown by the Btu value in heat returned to the furnace when interpreted in gallons of oil, pounds of coal, or cubic feet of gas.

The temperature carried in forge furnaces on unalloyed carbon steel, and on most alloyed steel, is high enough to give the necessary degree of heat to the waste gases. One other feature to be taken into account is the space available for the installation. A regenerative furnace occupies more space than one of the non-regenerative type and this additional space is an important factor at certain plants.

The difference in flame characteristics in a regenerative furnace as compared to one of the direct fired type is worthy of note. The principle reason for regeneration is increased efficiency which translated into dollars and cents means a very considerable saving where conditions are satisfactory for this type of furnace. The gain in heat is very easily calculated but is more apparent in actual output. The flame in a regenerative furnace is capable of closer manipulation as to oxidizing or reducing characteristics as compared to other types. Better combustion will also result from the better gas and air. Wherever powdered coal or natural gas is burned the saving is confined to the additional heat brought in by the air as it only is heated.

The heat control, as to temperature, in the renegerative type is under very close regulation, which is not so in the hand or stoker fired furnace. The change in furnace temperature cannot be so quickly made in hand fired furnaces due to the less exacting facilities for adjustment. The experienced forger desires what is generally known as a "mellow heat" and this can be more readily obtained with regeneration. The mixing of air and fuel is accomplished to a greater degree of perfection which fact eliminates to a large extent the liability for the existence of currents of unburned gas or of air. There therefore should be less oxidation as compared to other methods of firing. The labor cost will be small as the only work will be that of regulation. The fuel will be handled at a central plant and in an inexpensive manner comparatively.

In a regenerative fired furnace the fuel consumption will run approximately as follows:

Oil	per ton of output—39 gals.
Producer gas (coal)	per ton of output—450 lbs.
Powdered coal	per ton of output—400 lbs.
Natural gas	per ton of output—42,000 cu. ft.

Various types of furnaces have been built with the idea of maintaining a deep bed of fuel on the grate and operating on the semi-producer principle. The gain resulting from such furnaces is very small, if any. The sensible heat of the gas is utilized but the grate makes a poor gas producer.

Forge Furnaces—Non-Regenerative.

This type of furnace finds its field in plants where the pieces heated are not of the largest sizes, where the service is not continuous, or where the funds to be put into such equipment is limited. The latter is usually the leading consideration as the other factors are not necessarily controlling ones. It is entirely possible to heat large pieces with oil, powdered coal, or stokers with air at atmospheric temperature but it is preferable to heat the air.

By far the majority of forge furnaces are of the non-regenerative type and it is likewise true that the larger quantity of forgings are of medium or small size.

The furnaces under this heading are heated by oil, powdered coal, stokers, or hand fired. Individual stacks are the rule for carrying off the spent gases.

One of the main features in furnaces of the type under consideration, is to secure an evenly heated hearth as the hearth is long in comparison to the width. Usually there is a tendency to overheat near the bridge wall. Raising the bridge wall will help to remedy this difficulty provided sufficient space remains between the top of the bridge wall and the roof so that the heat will not be too confined in the combustion chamber.

The next feature of prime importance is to obtain the proper proportions for what is commonly called the "neck" and the roof directly over the neck. The neck connects the furnace proper to the stack. The "neck" must not be too large else the gases will pass out too swiftly and the furnace will be too cold at the "neck" end. If, on the other hand, the area of the neck be too small the furnace will not heat properly due to retarded combustion. There is only one way to determine the proper size of this opening and that is by experiment. Like many other problems connected with furnaces there is no formula which will apply. The Lauth furnace which met with much favor some years ago had a very steep drop in the roof directly over the "neck." The effect of this design was to increase the reverberatory effect and keep a large volume of hot gases in the furnace. The applicability of such a design will depend on the size of furnace and its service.

Another design which had quite an extensive use was the Stubblebein furnace. The object of this design was to increase the completeness of combustion by preheating the air. The rear wall of the combustion chamber was constructed so that air was drawn into openings near the base of this wall. This air passed through vertical circular passageways and entered the combustion chamber a few inches below the roof. In passing through the wall the air was heated. In the combustion chamber it met the partly oxidized gases with the result that these gases would be further oxidized. The same principle has been employed in many modifications. Any saving which might be obtained would be due to a more thorough mixing of air and gases. The preheating is open to question as the heat which is absorbed by the air is abstracted from the fire on the grate. It is hard to see where there can be enough increase in efficiency of combustion to offset the first cost and maintenance.

The coal consumption in furnaces of this type will depend on many considerations. Hand fired the coal per ton of output may run from 700 to 1,200 lbs. depending on size of furnace and amount of material heated, etc.

A furnace fired by powdered coal and heating very large pieces consumed 520 lbs. of coal per ton output. The temperature of this furnace averaged 2340 degrees F. Its efficiency was approximately 12 per cent.

Where waste heat boilers are provided the operation of the furnace, to show an appreciable saving, should be uninterrupted. There is no better means to economize heat than by a boiler but it must be kept running. Like many other engineering problems there is a point where the installation of a boiler is not economical. This will depend altogether on operating conditions. The investment when furnaces are installed with waste heat boilers is of course greater than where the boilers are left out. If the equipment stands idle the interest on the investment does not. Every plant has power conditions peculiar to itself and these must be taken into consideration.

Furnaces With Small Hearth Area.

Due to the small volume to be heated, gas, powdered coal and oil are generally employed as the heating agent in furnaces of this type. There are still a few shops where the pieces to be forged are placed on a bed of coke but such furnaces are comparatively few. There coke furnaces carry an excellent forging fire but the cost of coke and labor connected with its distribution have made this method of heating prohibitive.

Natural gas is still extensively used in some districts of Ohio and Pennsylvania but the cost of this fuel has advanced to 47c per 1,000 cu. ft. and it is being burned to a lesser extent each year.

Oil is still the predominant fuel but powdered coal is proving a strong competitor.

These small furnaces combine the heating and combustion chamber and it is vital to success that combustion be rapid. The aim must be to promote the intermixture of air and fuel and secure rapid ignition so that the heat will be generated instantaneously. The radiation from the walls of the furnace is most effective in hastening combustion. In these furnaces if the pressure is maintained and sufficiently high throughout the chamber there will be little trouble from unequal heating.

A comparative test recently run on two furnaces which will be designated No. 1 and No. 2 showed that No. 1 heated 96 pieces 2⅜ in. in diameter in 2 hours 20 minutes and consumed 32.31 gals. of oil. Thus the heating was at the rate of one piece every 1.46 minutes and the oil consumption per piece was .336 gals.

Furnace No. 2 heated 56 pieces in 2 hours and 18 minutes on an oil consumption of 30.81 gals. In this furnace one piece was heated every 2.46 minutes.

The hearth of both furnaces was 13½ in. deep by 4 ft. 1½ in. wide.

The above tests are not cited as ideal operation conditions but the performance of No. 1 furnace represents the output of a furnace which is found in many shops. The efficiencies attained by furnaces in this country are not as high as those in foreign countries which is largely due to the fact that our cheap fuels have not forced us to economize in this respect.

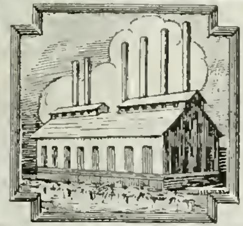
There is quite some difference in opinions relative to the rate at which steel should be heated. If heated too fast it is a well known fact, that the steel is injured by stresses which do not develop when the heating is slower. Every kind of steel has its peculiarities which will determine the rate of heating and subsequent treatment. Alloyed steels, being very sensitive to heat while the carbon steel will stand rougher usage. Experience will in the long run determine the most satisfactory forging temperature. There must be time for the necessary molecular changes to take place and this time cannot be shortened without spoiling the stock.

Probably the greatest criticism which can be offered in regard to small type furnaces is that in most instances they are too small for the work and the steel must be heated too rapidly.

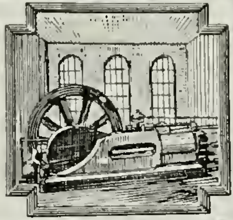
NEW OPEN HEARTH TALBOT FURNACE.

An open-hearth furnace of very large capacity has recently been developed by Mr. Benjamin Talbot, of Middlesbrough. The furnace has twin or plural hearths, connected by one or more ducts, enabling the metal to flow between, and in this way a larger volume of metal, estimated at 350-500 tons, may be treated. A central wall between the hearths overcomes the structural weakness of a single roof, heat energy being conserved, and the time for refining reduced.

A feature is the plan to tilt from the end instead of the side, and it is there where the regenerator chambers are located. The gases thus flow all in one direction, and the waste gases are carried from the tapping end of the stationary flue leading to the regenerators.



STEAM POWER DEPARTMENT



Steel Works Power Plant Management

Fixed Charges and Maintenance—Permanent Statistics for the Power Plant—Manner of Figuring Depreciation of Power House Equipment.

By ROBERT JUNE, Mechanical Engineer.

FIXED charges of the power plant are made up of a number of separate items, such as depreciation, interest on investment, rent, and administration. Maintenance consists of renewals and repairs, and the necessary labor required to make them.

Depreciation.

Depreciation results from a decrease in value of a given piece of apparatus, as a result of wear and tear, age, changing plant conditions, and changes in the art of manufacture of the particular apparatus which renders its further use inadequate. A convenient classification of the various forms of depreciation follows.

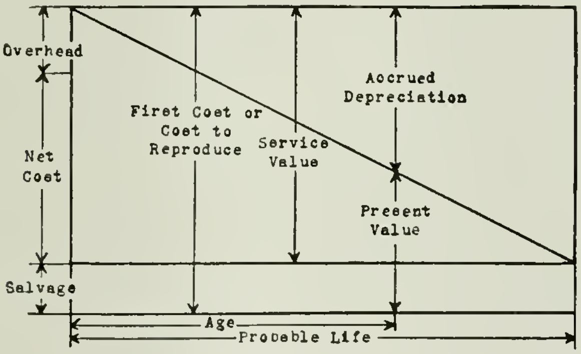


Fig. 1.

Complete Depreciation—This results from a gradual and even decrease in value, as the result of wear and tear.

Obsolescence, Inadequacy and Destruction—Marked improvements in the design of certain type of apparatus may render the use of the older type uneconomical, thus prematurely shortening its life.

Inadequacy is the result of increased demands upon capacity which renders it necessary to discontinue the use of a given machine, or the result of changing plant conditions which render the services of a machine of a given type no longer necessary.

Destruction is the result of accident. The possibilities of accident should be covered by insurance as fully as practicable. As they cannot be anticipated, it is difficult to set up a proper reserve for them. Obsolescence and inadequacy can, at times, be anticipated, and when this is the case, definite reserves should be set up to compensate for them. Whether there is reason to expect them, or not, some reserves should be set up in these days of rapid developments in the mechanical arts.

Incomplete Depreciation—This is due to unusual wear and tear of the sort which is apt to fall at irregular

TABLE I.

Approximate Useful Life of Various Portions of Steam Power Plant Equipments.

	Years
Belts	8
Boilers, water-tube	25
Boilers, fire-tube	20
Buildings, brick or concrete	40
Buildings, wooden or sheet iron	15
Chimneys, self-sustaining steel	30
Chimneys, guyed sheet-iron	10
Condensers, Jet	25
Condensers, surface	20
Coal conveyor, bucket	15
Coal conveyor, belt	10
Engines, slow-speed	25
Engines, high-speed	20
Economizers	20
Generators, direct-current	20
Generators, alternating-current	20
Heaters, open	25
Heaters, closed	20
Motors	20
Pumps	20
Piping, ordinary	12
Piping, first-class	20
Rotary converters	20
Soot blowers	8
Storage batteries	15
Stokers	12
Turbines	25
Transformers	20
Wiring	15

intervals in large amounts. Depreciation may be handled by several methods, as follows:

(1) To charge to earnings in good years and credit to depreciation reserve such amounts as the profits from operation permit.

(2) To charge to earnings the depreciation as it matures and necessitates renewals.

(3) To charge to earnings and credit to depreciation reserve annually a certain percentage of the cost determined by the average weighted life of the property.

It is quite common practice in power plant work to set up an average annual depreciation and allowance based on the original cost of the equipment, less its value as junk or salvage, and to spread this depreciation over a period of years approximating the assumed life of the equipment. Table I gives the approximate useful life of the most common type of power plant equipment, based on the assumption that they are properly handled and cared for, and that maintenance and repairs are kept up. This table does not account for obsolescence or inadequacy and its figures should be discounted on this account.

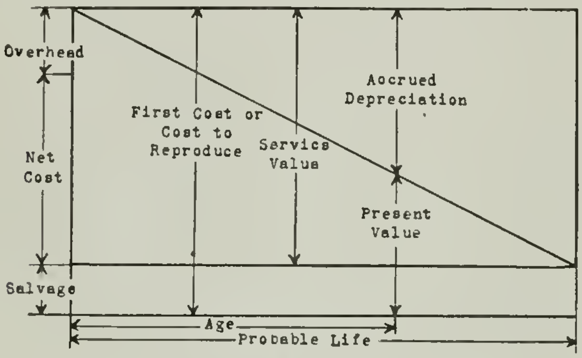


Fig. 2.

If we consider depreciation as including maintenance, we should properly set aside as a reserve a fixed percentage for the decreasing value of the equipment to represent the unmatured depreciation. In this way we equalize matters by making the depreciation allowance larger when repairs are smallest and vice versa, depreciation is smallest when repairs are largest, as the end of the useful life of the equipment approaches.

Depreciation reserves may be accumulated therefore either on the "straight-line" or "sinking fund" method.

Straight-Line Method—In the straight-line method, if we assume that the total investment, less salvage, is divided by the expected life of the equipment, we will have the amount in money which should be allowed each year to cover the accrued depreciation. This is the simplest method. It is illustrated in Figure I. Probable age of equipment may be determined from Table I with discounts as noted, to take care of obsolescence and inadequacy. In utilizing this method, the original cost is considered as including the net cost of labor and material, plus overhead, which includes insurance charges, fire and liability insurance, interest on investment during construction, installation, and, where the entire plant is being built, financial, legal and organization expenses.

Sinking Fund Method—In utilizing the sinking fund method, we set aside a fixed sum per annum which must be allowed to accumulate at compound interest. The money thus set aside, plus accumulated interest, must be equal to the original cost of the equipment, less salvage value, at the end of the assumed life of the equipment. Again we have reference to Table I for the life of the equipment, and again we must make proper discount for obsolescence and inadequacy.

Figure II graphically illustrates a convenient method of determining the rate of depreciation in connection with the use of the sinking fund method. Table II may conveniently be used in this connection.

TABLE II.

Rate of Depreciation.

Per Cent of First Cost.

Assumed Useful Life.	Rate of Interest, per cent						
Years.	4	4.5	5	5.5	6	7	8
2	49.02	48.90	48.78	48.66	48.54	48.31	48.07
3	32.03	31.87	31.72	31.56	31.41	31.10	30.80
4	23.55	23.39	23.20	23.03	22.86	22.52	22.19
5	18.46	18.28	18.10	17.19	17.73	17.40	17.04
6	15.08	14.89	14.70	14.53	14.33	13.97	13.63
7	12.66	12.46	12.28	12.09	11.91	11.15	11.20
8	10.85	10.66	10.47	10.28	10.10	9.74	9.40
9	9.45	9.26	9.07	8.88	8.70	8.34	8.00
10	8.33	8.14	7.95	7.76	7.58	7.23	6.90
11	7.41	7.22	7.04	6.86	6.68	6.33	6.00
12	6.65	6.46	6.28	6.10	5.92	5.60	5.27
13	6.01	5.83	5.64	5.47	5.29	4.96	4.65
14	5.46	5.28	5.10	4.93	4.75	4.49	4.13
15	4.99	4.81	4.63	4.46	4.29	3.97	3.68
16	4.58	4.40	4.22	4.06	3.89	3.58	3.30
17	4.22	4.04	3.87	3.70	3.54	3.24	2.95
18	3.90	3.72	3.55	3.39	3.23	2.94	2.66
19	3.61	3.44	3.27	3.11	2.96	2.67	2.47
20	3.36	3.19	3.02	2.87	2.71	2.44	2.18
25	2.40	2.24	2.09	1.95	1.82	1.58	1.36
30	1.78	1.64	1.50	1.38	1.26	1.06	0.88

Interest on Investment.

Interest on investment should cover not merely a percentage of the original net cost but it should also include overhead, such as insurance, engineering fees, office charges, cost of superintendance, interest on money paid in advance of the operation of the equipment, etc., the point being to include everything which enters into the expense of putting the equipment into service.

If the equipment, or building, in the case of a complete power plant is covered by mortgage, or bond issue, the interest rate must be high enough to include the complete interest on the mortgage, or bond, as well as any differential between the total gross cost and the amount of the bond or mortgage.

If the new equipment or building is paid for out of surplus previously earned in the business, interest should be charged at the rate which the money would earn if invested in other branches of the business or which it would earn if placed out at interest.

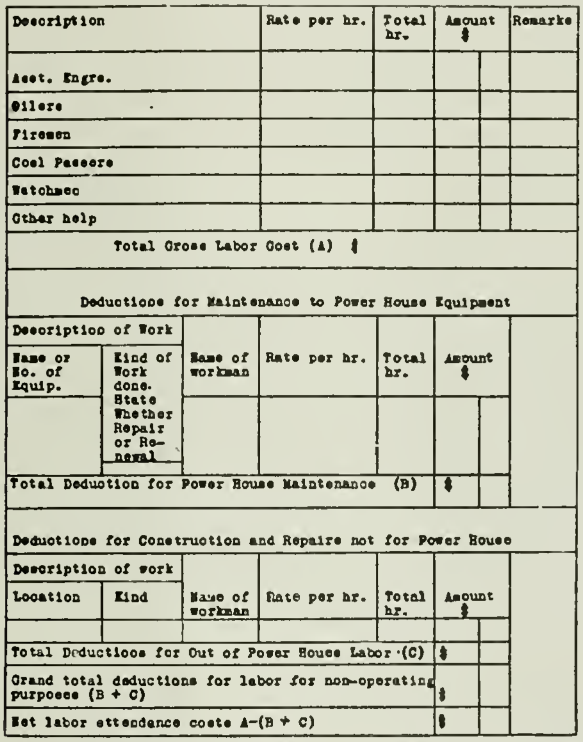
At this point, it is well to draw a distinction between repairs and renewals on one hand, and additions on the other. Repairs and renewals which do not increase the value or efficiency of the equipment beyond its former value must be charged to operating expenses. Additions, such as accessories which increase the value of the equipment, should be considered as capital investment. In the case of obsolescence or inadequacy, which has not been anticipated or entirely charged off in former years, only that portion of the cost of replacement above the cost of renewal of the old equipment should be charged to capital value. The remaining depreciation which has not been anticipated, must be charged to operating costs.

It should also be remembered that as depreciation occurs capital value declines, so that the amount of interest set aside each year will be less as time goes on.

Insurance.

Three classes of insurance are usually required in the power plant. First, on building; second, on equipment; and the third, liability insurance, on employees. On the first two classes, the premium is in direct relation to the value of the plant and equipment. The premium on the third class bears no relation to the cost of physical equipment, being based on the cost of labor and the hazards of employment.

Property Insurance — The relative premium on building insurance remains approximately the same year after year. However, it is extremely important to remember that when additions or alterations are made to the plant, that additional insurance should be provided. Changing replacement values of plant and equipment should also be taken into consideration. Thus, a building erected in 1912, for example, of good construction and with an estimated life of 40 years, would in 1920, if building costs had remained the same as in 1922, be properly insured for three-fourths of its original cost. However, as building costs have approximately doubled in the past ten years, the insurance should be based on the replacement cost today, less depreciation which would mean that the building should be insured at 1½ times its original cost.



Description	Rate per hr.	Total hr.	Amount $		Remarks
Asst. Engrs.					
Oilers					
Firemen					
Coal Passers					
Watchmen					
Other help					
Total Gross Labor Cost (A) $					

Deductions for Maintenance to Power House Equipment

Description of Work						
Name or No. of Equip.	Kind of Work done. State Whether Repair or Renewal	Name of workman	Rate per hr.	Total hr.	Amount $	
Total Deduction for Power House Maintenance (B)					$	

Deductions for Construction and Repairs not for Power House

Description of work						
Location	Kind	Name of workman	Rate per hr.	Total hr.	Amount $	
Total Deductions for Out of Power House Labor (C)					$	
Grand total deductions for labor for non-operating purposes (B + C)					$	
Net labor attendance costs A-(B + C)					$	

DAILY REPORT SHEET FOR POWER PLANT LABOR

Fig. 3.

Changing hazards must also be taken into account. If the fire hazard increases, the insurance companies will be found to be very prompt to cancel the policies in force and place in effect new ones at higher premiums. Should the fire hazard decrease, the owner should have the old policies cancelled and new ones issued, based on the lessened risk.

Equipment Insurance—Equipment insurance should be based on replacement value just as in the case of building insurance. If old machinery is replaced by new the policy should be revised to take this new value into consideration in order to secure adequate protection.

Liability Insurance—Liability insurance has come to assume a very important place in power plant costs. The premium, as a rule, is based on the pay roll, being divided however into a number of sections, each carrying a different premium depending upon the hazards of the individual class of work. As the premium may run anywhere from one to ten per cent of the actual cost of labor it forms a very important item and should not be neglected.

The first point is to ascertain the exact amount of time put in by the various power plant employees on various classes of work, bearing different premiums. For this purpose a daily report similar to that shown in Figure III is desirable. This, in addition to serving as a check on insurance premiums, may also be used for purposes of efficiency study in order to determine whether any undue proportion of time is being put in on certain classes of work.

In going into the various classes of insurance in detail, our purpose is to point out that insurance is much more of a variable than is generally supposed and that the insurance costs for a given period should not be assumed to be in definite relation to the first cost of equipment or in definite relation to liability but that they should be ascertained exactly for the period covered by the cost analysis.

Building and equipment insurance is, of course, a fixed charge. Liability insurance is sometimes considered a part of the cost of labor and is simply added thereto as an operating expense. However, it is more simple to regard liability insurance as a fixed charge.

Rent.

The value of the ground on which the power plant is built determines the amount to be charged up to rent. Where the power plant is merely one of a group of buildings, as in the case of a factory power plant, the rental should be in proportion to the amount of ground occupied by the power plant, coal pile, etc., as compared to the other buildings. Where the power plant stands alone as in the case of a central station, the value of the entire real estate is based for rental charge. Here again we have to take into consideration changing real estate values. However, adjustment and rental charges need ordinarily be made not oftener than once a year.

Administration Expenses.

This covers such items as salaries of officers, clerical wages, office supplies, office rent, interest and depreciation on equipment, depreciation and repairs on office equipment, insurance on office equipment, postage and stationery, telephone and telegraph, legal expenses, and where power is sold as well, advertising and sales expenses. In the case of a central station, all of the above items must be charged against the cost of producing power. If the central station has other lines of activity, they must be proportioned in relation to the expenses incurred by the various departments of the business.

FIGURE IV.

Fixed Charges—

Type of Equipment..

Plant No.......... Building No..

Location ....

Manufactured by..

Address ....

Date installed.................................By whom..

Brickwork and foundation put in by.. Date...............................

	Total Investment to Date	Interest on Investment at % Annually	Depreciation at % Annually	Rent (Based on proportionate space in building occupied by each machine)	Overhead (Based on proportionate share of taxes, insurance, office expenses, etc., for each machine	Total Annual Fixed Charges
COST OF FOUNDATION						
COST OF SETTING						
COST OF BOILER						
COST OF INSTALLATION						
Total Original Investment....................						

ADDITIONS

(Do not charge wages of regular plant attendants whose time would go on anyway, against additions)

Date	Character	Material furnished by	Cost	Labor by	Cost

In the case of a factory power plant, power becomes a production expense and the overhead charged against the power plant should be in relation to the total investment, and also to the total labor expenses in the factory and the total labor expenses in the power plant.

With uniform production, administration expenses will ordinarily vary but slightly from month to month. It should be ascertained each month and figured into the cost of power. Right at this point, the writer enters the plea that the men in actual charge of the production of power be regularly supplied each month with a statement from the accounting department showing all the charges set up against the power plant for interest, depreciation, insurance, rent, administration expenses and maintenance. These figures are all too commonly regarded as a secret. Just why this is so is not clear. The figures are usually of not the slightest value or interest to any one outside the plant nor would their possession by the operating men embarrass the management in 99 plants out of 100. Giving the operating men these figures indicates first, confidence in the integrity of the men and secondly, confidence in their ability to suggest ways and means of reducing some of these charges. Finally, it tends to curtail waste and extravagance, where such exist.

Figure IV indicates a form of record which should be kept in the power plant, one sheet for each important piece of equipment. This is not a formal accounting record—its purpose is to keep the men in charge of power plant operations fully informed of the nature and extent of the investment and the various types of equipment, and the cost of operating each individual unit. Its value will depend upon the individual men and their interest in their work.

FIGURE V.

Maintenance Cost Record.

Type of Equipment........................

Plant No..........Building No............

Location ....

Manufactured by..

Address ....

Name and Address to call for repairs........................

Date installed................ By whom....................

Brickwork put in by..

Repairs.

(Do not charge wages of regular plant attendants, whose time would go on anyway, against repairs)

Date	Character	Material Furnished by	Cost	Labor	Cost	Total cost repairs to date

Maintenance.

Maintenance and repair cost records should also be kept in the power plant. Again, this is not for formal accounting purposes. Its value to the operating men is to tell them where they are at with respect to the cost maintenance of various types of equipment. Maintenance, of course, refers to the expense of keeping the plant in running order over and above the cost of attendance. It does not refer to the replacement of new units but it includes the cost of repair parts and the cost of labor over and above that of keeping plant attendance, whose time would go on anyway whether they were engaged on repair work or not.

Figure V offers in convenient form a means of keeping track of the maintenance costs in the power plant. One of these sheets should be used for each machine of any size and the accounting department instructed to place at the disposal of the operating men any needed information regarding the costs, which will enable them to keep these records with approximate accuracy.

RECENT BOOKS OF INTEREST TO BLAST FURNACE OPERATORS.

By E. H. M'Clelland
Technology Librarian, Carnegie Library of Pittsburgh

Rate of Driving.

Greenwood, William Henry—Iron: its sources, properties, and manufacture, with numerous engravings and diagrams; revised and partly rewritten by A. H. Sexton. 225 p. 1907. Cassell.

Deals with the output of the furnace on p. 158-159.

Johnson, J. E., Jr.—Commercial considerations concerning the blast furnace. 1916. (In Metallurgical and chemical engineering, v. 15, p. 235-244.)

Considers on p. 237-238 the most economical rate of driving for furnaces and the effect of the rate of driving on profits. This article is the same as Chapter XIX of "Principles, operation and products of the blast furnace" by this author.

Johnson, J. E., Jr.—Principles, operation and products of the blast furnace. 551 p. 1918. McGraw.

Chapter XIII, "The rate of driving the furnace," p. 302-313. The most economical rate of driving for furnaces and the effect of rate of driving on profits are treated on p. 512-515.

Johnson, J. E., Jr.—Rate of driving the blast furnace. 1916. (In Metallurgical and chemical engineering, v. 15, p. 21-26.)

Discussion of the best rate of driving, giving consideration especially to the effects upon the regularity of the settling of the charge, fuel consumption, power required for blowing, flue dust lost, and the life of the lining. This article is the same as Chapter XIII of "Principles, operation and products of the blast furnace" by this author.

Turner, Thomas—Metallurgy of iron. 486 p. 1915. C. Griffin.

Gives brief consideration (on p. 125) to the rate of driving of a blast furnace.

See also "Brassert," below.

Volume and Pressure of Blast.

Brassert, Hermann A.—Modern American blast furnace practice. 1914. (In Year book of the American Iron and Steel Institute, 1914. p. 15-69.)

Discussion, p. 70-113.
Says on p. 54, that "uniform practice demands that the blowing engines be so governed as to deliver a constant quantity of air and not to maintain a constant pressure." Pays some attention to rate of driving furnace under "Operation."

Grosswendt, Carl—Turbo blower and compressor regulators. 1916. (In Blast Furnace and Steel Plant, 1916, p. 426-428.)

Supplementary to preceding article. "Deals with the devices that bring about the desired results."

Grosswendt, Carl—Regulating turbo blowers on compressors. 1916. (In Blast Furnace and Steel Plant, 1916, p. 76-78.)

Discusses "means for obtaining specified operating conditions under varying handicaps."

Loewenstein, L. C.—Volume regulator for blast furnace engines. 1917. (In Transactions of the American Society of Mechanical Engineers, v. 39, p. 843-882.)

Discussion, p. 882-884.

The same, condensed. 1918. (In Journal of the American Society of Mechanical Engineers, v. 40, p. 224-233.)

Deals with the use of a constant volume governor and a volume corrector to take account of variations in atmospheric conditions.

Marks, Lionel S., ed.—Mechanical engineers' handbook. 1836 p. 1916. McGraw.

Gives on p. 1530-1531 brief consideration to the advantages of the centrifugal compressor, and its application with a constant-volume governor to blast furnace work. Describes two kinds of constant-volume governors for blast furnace purposes on p. 1539-1540.

Rice, Richard H., and Moss, Sanford A.—Blast furnace and steel mill power plants. 1917. (In Proceedings of the Engineers' Society of Western Pennsylvania, v. 33, p. 81-115.)

Discussion, p. 115-130.
Devoted to the use of the turbo-blower for blast furnace work. Includes a description of a constant-volume governor and a "volume corrector" to take account of variations in atmospheric conditions, manufactured by the General Electric Company.

Rice, Richard H.—Turbo blowers for blast furnace blowing. 1914. (In Transactions of the American Institute of Mining Engineers, v. 50, p. 104-126.)

Discussion, p. 126-142.
Includes a description of a constant-volume governor.

Smoot, C. H.—Air-volume regulation in smelting and refining furnaces. 1919. (In Engineering and Mining Journal, v. 107, p. 654-656.)

Description of author's regulating apparatus for obtaining a constant volume of air in blast furnaces. Says it has always been customary to operate iron blast furnaces with a constant volume of air.

SULPHUR IN COKE

The general problem of decreasing the sulphur in metallurgical coke and devising desulphurization processes demands that some knowledge be had of just how the sulphur in coke occurs. Unfortunately this is not known and has led to several futile attempts to determine in what form the sulphur occurs in coke. A new method of attack has been outlined by the Bureau of Mines which promises to gve much more information on this subject. This method makes use of the passage of hydrogen through the hot coke, thereby giving a means for measuring the dissociation pressure of the carbon-sulphur combination. Application of the phase rule to these results will indicate whether the sulphur is present as a compound, a solid solution, or adsorbed. The results so far obtained by the Bureau of Mines seem to indicate the presence of a compound, but further work will be required to substantiate this and study its properties.

PRODUCTION TOPICS

STRUCTURAL STEEL—IT'S PAST AND FUTURE.

By George H. Danforth

Steel construction, as it exists today, is the heir of that period, prior to the Civil War, which saw the rise and development of the structural uses of wrought iron for bridges also, to a much more limited extent, for certain forms of building work. In England both wrought and cast iron were used in construction much earlier than this but in this country, the abundant supplies of timber and the imperative need of building cheaply, delayed our use of metal to a later date. It was during this period that the theoretical work was done whereby we were taught the analysis of structures and the stresses that come from various types and conditions of loading, material to resist these stresses being proportioned in different ways to suit the ideas or whims of the designer. You have only to look over some of the early handbooks and treatises to see how our predecessors labored to find the best and most economical way, according to their lights, to solve their problems and make their structures safe. The patent office was full of the efforts of these men for at that time, the idea was rampant that the patent was the thing to protect their ideas. Few of the structures of this period remain to tell tale, having been superseded in the course of time. It is to this time that the man and the Whipple truss belong, also the Post truss, now all practically extinct. The Pratt truss is still with us but the rest have gone. Once in a while there will appear a man with a patent on some structural design that he thinks is new and valuable, but nine times out of ten, it will be found on analysis, that the new patent is but one of these old ideas that have been so dressed up by the skillful patent attorney as to get by the patent office examiner.

The great expansion of the railroads after the Civil War, was the cause of the growth of many shops for metal construction work. Some of these shops have been originally built for the making of "combination" bridges, as they were called, having wood for top chord and posts and with iron rods for tension members. The injunction of the wood and iron members being usually made by means of a casting. It was but natural that these shops should develop and multiply as wrought iron became cheaper and as the loadings became heavier. The directing minds of these shops became eventually, the designers and fabricators of the all metal bridge, as well as the occasional metal trainshed. At this time, there was little doing in the way of metal buildings of any other type. The first extensive use of metal skeletons in the ordinary commercial building was made when part of the Western Union Building in Chicago was constructed. This was followed in 1883 by the Home Insurance Bldg., also in Chicago, where the first Bessemer steel beams were used, in connection with cast iron columns to form a complete frame. It is well to stop a moment and think how recently steel construction has developed when you are trying to form an idea to what it's use may be in the future.

In considering this future, it should be borne in mind, that it is only within a few years, that there has been any real rival to steel as a construction element in structures of any size. Wood has been displaced on account of lack of strength and high cost. For certain types of factory construction, known as mill construction, it is still favorably regarded but the high cost and tendency to dry rot is crowding it out, even there, and relegating its use to ordinary house construction where loadings are light and poor grades can be used. Even here, its combustibility is against it. The growing idea that construction shall be incombustible, if not fireproof, is practically certain to cause its abandonment; except for the finish or for temporary structures, where ease of making connections and re-use of the material after the structure is abandoned, make its use advisable.

Concrete has been used of late years, to a considerable extent, and has had many enthusiastic advocates. In fact, its standing today has been more than impaired by this very enthusiasm, causing it to be used in places where it has really had no business to be even considered. Compared to structural steel, it is heavy, and cumbersome and if it is to displace structural steel there will have to be ways found to insure its standing the weather, at least in this climate. The tendency of concrete to spall under heat is also against it. To spall, when used as an insulator against fire is bad enough, but when the spalling is from the very member on which you are depending for the strength of your structure, it is fatal. There is also the very serious objection to be urged, that it is subject to all the incidental defects involved in field work with no means of knowing what you have until it is in structure. You cannot test it beforehand to determine what you are going to get as a finished result.

Terra-cotta has been brought forward by some and quite a number of good sized arches and domes have been built, but so far they seem to have defied analysis and are constructed on emperical rules, the use of this material for anything aside from the few places where it serves a special purpose is hardly possible.

So far nothing has been developed that would indicate that the use of steel for "structural purposes" was on the wane, or that we are likely to see it displaced in the immediate future. Comparatively speaking, it is light in weight for the strength it possesses; there is no question as to determining its quality before it is incorporated into the structure or as to how it is connected after you get it there. It is not fireproof but it is combustible and if the use is such, that protection from fire is necessary, such protection can be readily applied. As made at the present day, it has to be admitted, that it will rust, when subjected to certain exposures, and as a protection against this we have been relying on various paints and coatings. It is not logical to have as the only protection against corrosion of a structure, costing many thousands of dollars, a microscopically thin film of oxidized vegetable oil or something that is equally tender and fragile. Some day there is no doubt but that we will produce a non-corroding steel, that will be commercially available for construction purposes and then the use of paint will be relegated to its proper sphere, that of finish and color only, and not then if we think the natural appearance preferable.

With the rise of structural steel, there developed a mania

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*Abstract of paper presented at Engineering Society of Western Pennsylvania.

PRODUCTION TOPICS

for diverse specifications both for quality of the material and for workmanship on the completed structure. Every railroad and nearly every engineer had its own, and from their view-point the only right and proper one. This led to endless confusion, with their minute variations, an impossible situation from a production stand point, was created. We still have plenty of specifications of various tendencies, but thanks to the labors of some of our engineering and other technical societies, they are getting to be more reasonable and for similar types of structures, they are also getting to be more uniform. There is still room for further progress in this direction and it is to be hoped that the time is not far distant when the specifications for quality will be reduced to one for each, of not more, than say, three or four types of structures. It is for work of this character, that many of these Societies are to be most highly praised. Workmanship specifications have to a large extent grown more rigid as the years have gone by. Punched holes, originally universal, have been barred under certain conditions and reamed holes or holes drilled from the solid have been called for in high class work. These constitute a serious item to be considered. There seems to be a tendency, however of late, at least in some quarters, to let up in this regard, as if it were considered that the results obtained, were not worth the extra expense. The same can also be considered true of the epidemic of sand-blasting, and later of pickling to remove mill scale, that for a time ran rampant in certain places. Possibly the absence of easy money among our railroads and their need of getting value received, may have had something to do with this change.

PHYSICAL TESTING OF COKE.

The physical characteristics of coke is a matter of great importance to the blast furnace and foundry men. Tentative definitions of terms relating to coke have been formulated by the Bureau of Mines and submitted to the American Society for Testing Materials. Data are being assembled as to the methods in general use in making "shatter" and "hardness" tests on coke. The Bureau of Mines realizes that if the results of such empirical tests are to be used to the best advantage they must be standardized in order that the results obtained be comparable. It is proposed to get as much information together as possible as to the methods of conducting these tests and from these data tentative methods will be submitted to the American Society for Testing Materials for the making of "shatter" and "hardness tests on coke.

TRENT PROCESS FOR CLEANING COAL.

The efficiency of the Trent process in cleaning coal has been determined by the Bureau of Mines for typical coals of the United States. The point of superiority of the Trent Process over ordinary washing methods is the high combustible recovery obtained, in some cases as high as 99 per cent. Low-grade sub-bituminous coals and lignites do not respond readily to treatment by the process. The process is not efficient in removing sulphur present as pyrite in the bituminous coals; with anthracite coals, sulphur removal is good. The relation betwen fineness of grinding and ash separation has been determined on typical coals pulverized to sizes as small as 10 microns, (.01 mm).

JANUARY FABRICATED STEEL BUSINESS RELATIVELY GOOD.

In January 72,100 tons of fabricated structural steel work was contracted for throughout the United States, against 71,500 tons in December and 63,000 tons the monthly average for 1921. In January, 1921, the total was only 32,000 tons, but in January, 1920, it was 135,000 tons. Taking into account the hesitation evident in consummating investment enterprises, the fact that January is slightly better in tonnage than December may be significant. In the last ten years January has always shown a falling off from December with two exceptions, 1913 and 1914. January bookings for a decade have averaged 82,800 tons, while December bookings have averaged 111,200 tons. Thus January is about 15 per cent better than the 1921 rate and not quite 13 per cent under the January rate. February has normally been 10 per cent better than January.

The statistics of the volume of business taken by the bridge and structural shops of the country are those of George E. Gifford, secretary of the Bridge Builders and Structural Society, 50 Church Street, New York. The January business indicates that 40 per cent of shop capacity was covered, the total monthly capacity being put at 180,000 tons.

HUMAN ELEMENT IN ENGINEERING.

The feature of the regular monthly meeting of the Engineers' Society of Western Pennsylvania, held in the Georgian room, William Penn hotel, Pittsburgh, Tuesday, February 21, at 8 P. M., was the presentation of a paper on the "Human Element in Engineering" by E. Atkin Starks, General Sales Manager of the Duravla Mfg. Co., New York. Mr. Starks stressed the importance of giving due consideration to the relations with employes in all engineering projects.

STEEL TREATERS MEETING.

To more directly serve members of the American Society for Steel Treating, sectional meetings have been instituted, the first of which will be held at the McAlpin Hotel, New York, March 3. Fourteen of the eastern and New England chapters will participate in this meeting. A variety of subjects will be discussed in the seven addresses which are scheduled. Attendance is not limited to members. The complete program follows:

11:00 P. M.—Registration.

1:30 P. M.—Address of welcome.

2:00 P. M.—Addresses: "Cold Headed Bolts — Their Metallography and Heat Treatment," illustrated, by V. E. Hillman ,Crompton & Knowles Loom Works, Worcester, Mass.; "New Developments on the Influence of Mass in Heat Treatment," by E. J. Janitzky, Illinois Steel Co., South Chicago, Ill.; "The Magnetic Testing of Small Case-hardened Chain," by A. V. DeForest, American Chain Co., Bridgeport. "Stainless Steel in Cutlery Use," illustrated, by F. G. Hall, R. Wallace & Sons Mfg. Co., Wallingford, Conn.; "Calite—A New Heat Resisting Alloy," illustrated, by G. R. Brophy, General Electric Co., Schenectady, N. Y.

6:00 P. M.—Informal dinner.

8:00 P. M.—Addresses: "Perfecting a Drop Forging," illustrated by J. H. G. Williams, Hartford, Conn.; "The Manufacture of Steel," illustrated, by B. H. Long, Carpenter Steel Co., Reading, Pa.

NEWS OF THE PLANTS

The Wallingford Steel Company, Wallingford, Conn., recently organized under state laws with a capital of $200,000, has acquired property near the end of Valley Street, on the east side of the Quinnipiac River, Wallingford, as a site for the erection of a new plant for the manufacture of rolled and other steel products. The initial works, plans for which are being prepared, will comprise three buildings, 100x130 feet, 100x300 feet, and 50x100 feet, all one-story. One of these structures will be equipped as a rolling mill. Ground will be broken at an early date. The company is headed by C. W. Leavenworth, F. A. Wallace and E. B. Cleborne, all of Wallingford.

The Evansville Structural Supply Company, Evansville, Ind., manufacturer of iron and steel products, is planning for the erection of a new steel fabricating plant, to be one-story, 100x200 feet, and estimated to cost approximately $40,000. The company is now operating a works at 215 First Avenue. Construction of the new plant will be commenced at an early date.

The Carnegie Steel Company, Pittsburgh, Pa., has work under way on the rebuilding of the blast furnace No. 4, at its Lorain, Ohio, works, and will have the structure ready for service at an early date. The company is also making extensions and improvements in its slag crushing plant at this location, and will install new finishing machinery in certain departments at the mill.

The Wheeling Steel Corporation, Wheeling, W. Va., has awarded contracts for the erection of a number of additions to its plants at Steubenville and Portsmouth, Ohio, for extensive increased capacity, and different features of the work will be inaugurated at once. At the Portsmouth mill, a new rod and wire plant will be constructed, the first noted to be equipped with a continuous rod mill of special design. In the wire-working department, the installation will include machinery for general wire-drawing, fence and nail production. New pickling, annealing and galvanizing machinery will be installed in these different branches of the works. A large boiler plant will be constructed, as well as a new gas producer department. New rolling mill machinery has been installed at the Steubenville plant, and still further expansion will be continued in this direction. New tables and transfers, shears, intensifiers and auxiliary operating equipment has been ordered, with an eight-stand, 19-inch continuous bar mill. A 35-inch blooming mill will also form part of the new equipment. Plans are under way for the erection of a new boiler plant at the Steubenville works, and at a later date it is proposed to install a complete new electric generating plant, provided with turbo-generators as prime movers to furnish all electric power required for the works. A new gas producer will be installed, utilizing space now given over to one of the skelp mills. A new storehouse and greater yard facilities will form a feature of the improvement work under way, and about 10 new electric traveling cranes will be installed, including two 150-ton ladle cranes. The entire program for the two plants calls for an expenditure approximating $5,000,000.

The Direct Steel Process Company, San Jose, Cal., now operating a temporary plant at Alameda, Cal., is planning for the erection of a new steel works in the vicinity of San Francisco, Cal., and is negotiating with the Chamber of Commerce at the latter place for a suitable site. It is proposed to commence work at an early date. H. Bardue, vice-president and general manager of the company, is in charge of the project.

The Maryland Steel Rolling Company, 1410 Fidelity Building, Baltimore, Md., has taken title to property at St. Helena, near Baltimore, for the erection of a new plant for the manufacture of steel bars and kindred products. Plans have been completed for a main building, 65x228 feet, with a number of smaller structures, and work will be commenced at an early date. A number of contracts are being placed for equipment, including a traveling crane. R. S. Baldwin, general manager is in charge.

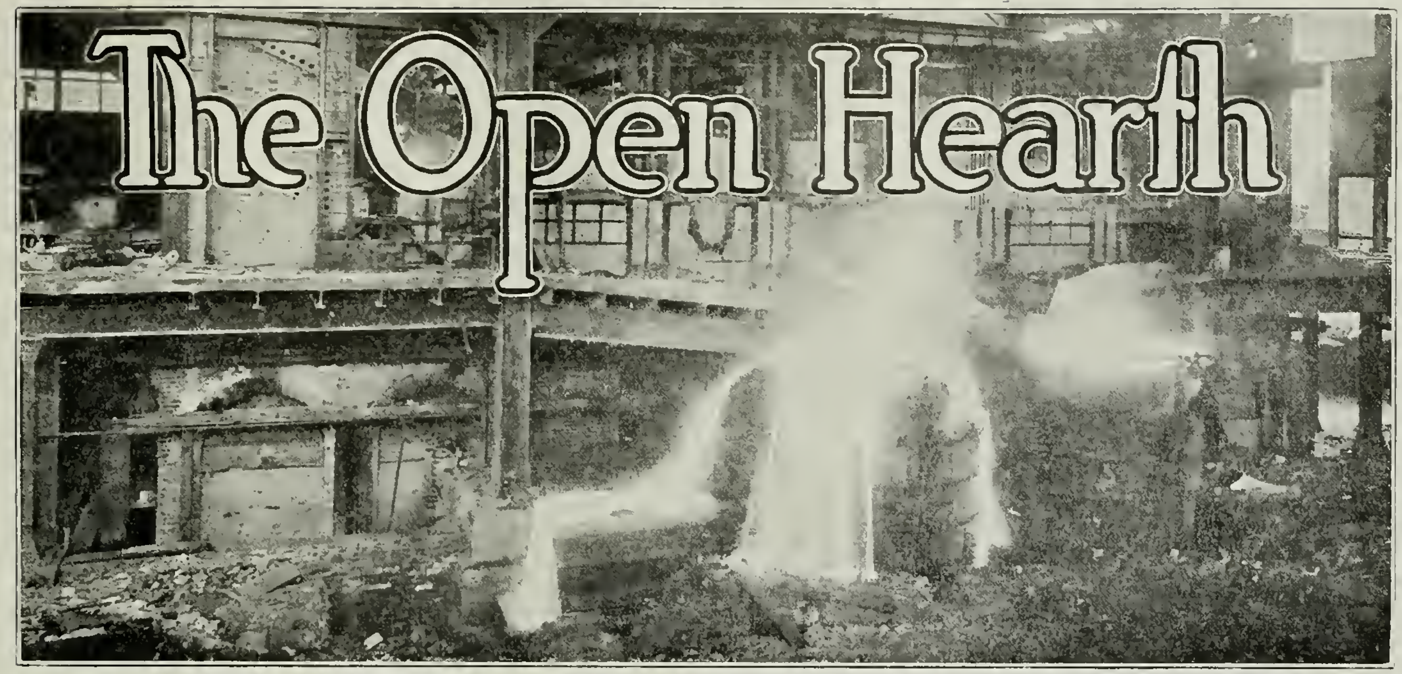
The Great Southern Steel Company, Chicago, Ill., is perfecting plans for the erection of its proposed new plant in the Birmingham, Ala., district, and will construct two new blast furnaces, with capacity of about 220 tons, at this location. Following a large steel mill will be erected, consisting of a number of buildings, all fully equipped for different branches of manufacture. The complete initial works will cost close to $1,000,000, including machinery. The company has a large tract of land in this section, including iron ore and coal properties in Etowah and other counties. The company is reported to have been negotiating for the purchase of the property of the White Iron & Coal Company, Gadsden, Ala., but with offers declined. The latter organization has engaged the Robert W. Hunt Company, Chicago, engineer, as operating manager of its local plant. The Great Southern Steel Company was organized recently under Delaware laws with a capital of $105,000,000. The board of directors will include J. S. Stearns of the Stearns & Culver Lumber Company, Ludington, Mich., and P. M. Stearns, a lumberman with closely affiliated interests; also, Judge H. W. Seaman, Chicago, and John I. Beggs, Milwaukee, Wis., identified with electric traction interests in this section. The company is represented by Charles E. Pain, attorney, First National Bank Building, Chicago.

The American Sheet & Tin Plate Company, Pittsburgh, Pa., has work under way on new pickling and galvanizing buildings at its Vandergrift plant, and will install considerable equipment for the different features of operaton. New furnaces will also be provided for the hot mills at the works.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., has work under way on the rebuilding of the No. 1 blast furnace at its Ensley, Ala., plant. Improvements in the power house at the plant will also be made.

The American Steel & Wire Company, Donora, Pa., is arranging for the relining of one of the furnaces at its local works, and has production under way at the other furnaces at the works, as well as the two furnaces at its Schoenberger plant.

The Republic Iron & Steel Company, Youngstown, Ohio, is increasing operations at its plant and has recently reopened two of the merchant bar mills following an extended shut down .



The Open Hearth

It was recently announced by F. J. Griffith, that he had resigned his position as vice-president and general manager of the Central Steel Co., Massillon, Ohio, but will remain with the company in his former capacity, having been re-elected at a recent meeting, when the reorganization of the company was completed. The reorganized company with the consolidation of formerly affiliated units, has practically the same organization as before. R. E. Bebb is chairman and president; C. E. Stuart, secretary and treasurer; C. C. Chase, vice-president, and in charge of the sheet division; H. M. Naugle, vice-president and in charge of the metal lumber division; J. M. Schlendorf, manager of sales; B. F. Fairless, superintendent and manager of operations; Myron Phillips, manager of production; E. C. Smith, chief metallurgist, and George D. Evans, purchasing agent.

* * *

John Stambaugh, director of the Brier Hill Steel Co., Youngstown, Ohio, leaves this week for a tour of Europe, accompanied by his wife.

* * *

At the annual meeting of the stockholders of the Inland Steel Co., Chicago, on January 31, former directors being re-elected and Gordon Battelle, Columbus, Ohio, was elected director to succeed Elias Colbert, deceased. L. E. Block and P. D. Block were re-elected chairman of the board and president respectively. Edward M. Adams was elected first vice-president to succeed G. H. Jones and W. D. Truesdale was elected secretary-treasurer. Other vice-presidents are H. C. Jones, E. J. Block, J. W. Lees, W. C. Carroll and Charles R. Robinson, the latter two having recently become affiliated with the company, as previously announced in these columns.

* * *

On February 14th, the George Washington sailed, carrying on board Mr. Evans F. Jones, of the Morgan Construction Co., Worcester, Mass., for a 64 days' trip to the Holy Land and other points of interest.

* * *

It was announced that A. J. McFarland, general manager, Portsmouth Ohio Works, Wheeling Steel Corporation, has been transferred to the Steubenville, Ohio, works of the company and will assume the position of general manager made vacant by the resignation of G. B. LeVan. G. W. Moore, general superintendent, Portsmouth works, has been promoted to the position of general manager, vice Mr. McFarland.

* * *

Walter H. Radtke, has resigned his position as chief metallurgist of the Canton Sheet Steel Co., Canton, Ohio, which position he held for several years.

* * *

R. M. Wolvin, president of the British Empire Steel Corp., has returned to Halifax, N. S., from England and Germany, where he had gone in an endeavor to sell ore from the corporations Wabana mines.

* * *

At the recent annual meeting of the Alan Wood Iron & Steel Co., Philadelphia, Richard G. Wood was elected president of their company. Jonathan R. Jones was elected vice-president. Both Mr. Wood and Mr. Jones had occupied these positions for many years prior to 1920. Two years ago they resigned these offices and Mr. Wood retired with the title of chairman of the board and Mr. Jones as vice-president.

* * *

G. B. Wickersham, secretary-treasurer and director of the Muncie Steel Supply Co., has organized G. B. Wickersham & Co., Pittsburgh, to handle scrap and to conduct a general business as auctioneers, appraisers, and liquidators. He will continue with the Muncie Co.

* * *

W. W. Scott, Jr., has announced his resignation as manager of sales in St. Louis for Carnegie Steel Co., the Illinois Steel Company, and the Tennessee Coal, Iron & Railroad Co., to become general manager of sales for the Laclede Steel Co., St. Louis, effective February 1, has been affiliated with one or more of the United States Steel Corporation's subsidiary companies since its formation in 1901.

* * *

Andrew H. Green, Jr., vice-president in charge of operations of the Solvay Process Co., Syracuse, N. Y., has been elected president of the Charcoal Iron Co., of America, Detroit, succeeding F. W. Blair who resigned at a meeting held January 26. Mr. Green was manager of the Solvay plant in Detroit up to two years ago, when he was transferred to the headquarters of the company. He was active in civic affairs at Detroit and was decorated by the French government for his services during the world war.

The Open Hearth

Eric A. Lof, of the power and mining department of the General Electric Co., Schenectady, has had the Royal Order of Vasa conferred upon him by the King of Sweden in recognition of meritorius services rendered his government. The decoration is similar to those of the legion of honor in France. Mr. Lof spent several months in Europe last year for the International General Electric Co., partly in connection with the extensive power transmission and railway electrification projects which are being planned by the Swedish government.

√ √

Charles Russ Richards, dean of engineering and director of the experimental engineering department of the University of Illinois, has been elected president of the Lehigh university. He succeeds Dr. Henry S. Drinker, now president emeritus at Lehigh. Mr. Richards is a graduate of Purdue University and a post-graduate of Cornell.

√ √

C. C. Boyden who has in the past been identified with various pig iron interests in the East and who for the past four months has been on the Pacific coast, has returned and is temporarily at Foxboro, Mass.

√ √

Joseph W. Powell, president of the Emergency Fleet corporation is to resume his former position as head of the Fore River Works, Quincy, Mass., of the Bethlehem Shipbuilding Corp., Ltd., when he retires March 4.

√ √

Louis F. Vonier, formerly manager of the Milwaukee office of the Federal Bridge & Structural Co., Waukesha, Wis., has become associated with the Central Steel Co., Massillon, O., as district representative of its National Pressed Steel Division in the Wisconsin territory. Mr. Vonier has opened new offices at 412 Matthews Building, Milwaukee.

√ √

W. Wallace McKaig recently succeeded W. J. Muncaster as vice-president and general manager of the Cumberland Steel Co., Cumberland, Md. Mr. Lancaster has retired. J. F. Stark was elected secretary and treasurer of this company to succeed Albert Charles, who remains a director of the company. Merwin McKaig is president of the company.

√ √

William J. Morris, for many years assistant treasurer Youngstown Sheet & Tube Co., Youngstown, Ohio, has been elected treasurer, succeeding Richard Garlick, resigned because of ill health. Mr. Garlick has been treasurer virtually since the formation of the company in 1900. He continues on the board of directors. For the past few years Mr. Morris has been practically acting treasurer. Walter E. Meub, secretary of the company and assistant to President James A. Campbell, was elected assistant treasurer, Mr. Garlick is now in the south with his family.

√ √

Robert A. McDonald, for a number of years manager, Crescent Works, Crucible Steel Company of America, Pittsburgh, has been promoted to the position of general superintendent of all plants of the company with headquarters in New York.

√ √

Albert H. Whipple, superintendent of the Whitin Machine Works, Whitinsville, Mass., recently received a 50-year service pin from the company. Mr. Whipple entered the employ of the Whitin company in January, 1872, as an apprentice and has had an unbroken service record ever since.

√ √

Frederick K. Vial, chief engineer Griffin Wheel Co., Chicago, and consulting engineer for the Association of Manufacturers of Chilled Car Wheels, will represent the last named organization at the convention of the International Railway Association at Milan, Italy, April 18 to 30. This will be the first meeting of the International Association to be held since 1910. This body ordinarily convenes every five years, but the last meeting, which was scheduled to take place at Berlin in 1915, was abandoned for obvious reasons.

√ √

James E. McKenny, for the past year superintendent of the Standard Spring Co., Cleveland, has resigned and returned to his former home in Worcester, Mass. Before going to Cleveland he was located in Youngstown, O. Mr. McKenny is a former superintendent of the National works of the Wickwire Spencer Steel Corp., Worcester, and at one time was production manager for the former Morgan Spring Co. of that city, now the oMrgan works of the Wickwire Spencer Steel Corp.

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James B. Taylor has been elected a director of the American Can Co., succeeding the late Henry R. Hoyt.

Some Pointers on By-Product Coke Oven Operations

REVIEW OF COKING IN THE PACIFIC NORTHWEST.

The coking industry of the Pacific Northwest during 1921 has reflected the general industrial depression common to the country at large. In addition, a strike of coal miners, which began in March and which is still in force in most of the commercial mines in Washington, cut off the production of coal in the principal coke producing county in the state.

Practically all of the coke produced in Washington, which is the only state west of the Rockies manufacturing coke, comes from an area closely tributary to Seattle and Tacoma. Tacoma is the county seat of Pierce county, which contains the principal deposits of coking coal and is the leading producer of beehive coke. The total number of beehive ovens in the state is 494; of these, 409 are in Pierce county, the remainder are in King and Skagit counties, not far from Seattle. The Seattle Lighting Company has a battery of 5 by-product ovens of the Klonne type made by the National Chamber Oven Company consisting of 20 chambers. This plant operates primarily to produce illuminating gas for the city of Seattle, but its coke is used for domestic, industrial, and, to a lesser degree, for metallurgical purposes. All of the beehive coke is sold for foundry and smelter use.

Much Coal of Fine Sizes is Produced Which Necessitates Washing.

In normal times all of the coke produced is made from washed coal. The seams producing coking coal are badly folded and stand at high angles, making mining difficult and causing large percentages of fine sizes. Admixture of foreign material, both from the seams and from the enclosing walls, make washing necessary. Jigging has been the customary practice, but, recently, considerable attention has been given to the preparation of fine sizes on concentrating tables, with very encouraging results. The ash content of Washington coke is rather higher than in other localities because of the nature of the coal and the difficulty in economically receiving the intimately mixed ash-bearing constituents. On the other hand, sulphur and phosphorus are low.

The great bulk of the beehive product is 48-hour coke, although 72-hour and 96-hour coke are also produced. The former is almost entirely used in nonferrous smelting; the latter in foundry use. The by-product coke made at Seattle is a 24-hour product.

Market For the Product and Recent Production Figures.

The market, in the past, has extended from California to Alaska. The coast district of British Columbia, until the establishment of the by-product plant at Anyox, absorbed a considerable portion of the production. The copper smelter at Tacoma took a large bulk of the production, but the closing down of the blast furnaces in favor of reverberatory smelting eliminated a large market. The blast furnaces, however, are being put into service again and there is a revival of the market for Pierce county coke.

It is estimated that the plants in the state have a potential or possible production of 300,000 tons annually. This production has, however, never been reached. The banner year was in 1915 when 136,522 tons were produced. The 1920 production was 69,282 tons, made up of 42,998 tons from the beehive ovens and 26,284 tons from the by-product ovens. Production figures for the past few years are indicated below:

Year.	Coke Produced* (Short Tons)	Total Value of Coke at Ovens.	Value of Coke at Ovens Per Ton.	Yield of Coal in Coke (%)
1915	136,552	$ 700,832	$5.13	66.7
1916	125,872	662,987	5.27	61.5
1917	122,758	906,318	7.38	59.7
1918	123,788	1,092,741	8.18	60.6
1919	65,332	565,356	8.65	63.4
1920	69,282	361,582	5.22	60.5
1921	3,600–			

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* Includes by-product coke.
– Eleven months only.

The production of by-product coke is shown by the following figures:

Year.	Coke Produced* (Short Tons)	Value of Coke.
1914	6,751	$ 36,585.66
1915	30,182	158,472.17
1916	29,516	159,321.69
1917	27,635	210,857.81
1918	26,260	233,815.01
1919	26,955	207,116.23
1920	26,284	162,309.92
1921–	22,257	154,136.91

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* Does not include breeze.
– Eleven months only.

The total 1921 production will be the lowest in many years. The output of by-product coke has been fairly steady because of the fact that the plant is primarily operated for gas. The production up to December first is 22,257 tons, valued at $154,136.91. The average value has been $6.925 per ton.

The beehive production this year has practically all come from the ovens of the Wilkeson Coal & Coke Company. A small quantity of 72-hour coke for foundry purposes, amounting to 1,272 tons, was produced during the first three months of the year at Wilkeson, and some 700 tons is reported to have been produced by the Western Coke and Collieries Co., at Snoqualmie. Resumption of blast furnace copper smelting at the Tacoma Smelter, a subsidiary of the American Smelters Securities Co., has revived the production of 48-hour coke during the past three months. The total production of beehive coke for 1921 is estimated to be 4,200 short tons. The average value of this coke at the ovens is approximately $8.00 per ton.

The grand total for the state for 1921 is estimated to be 30,000 tons valued at approximately $210,000.

The Coast district of British Columbia has two coking establishments,—one, a beehive plant at Union Bay, owned by the Canadian Collieries (Dunsmuir) Lt., consisting of 200 ovens; the other a by-product plant, erected in 1918, by the Granby Consolidated Mining, Smelting and Power Co., at Anyox, which consists of a battery of 30 ovens made by the Gas and Coke Company of America.

The reported figures of production for the Anyox plant in 1910 are as follows: Coke 77,290 short tons; breeze, 2,896 tons; tar, 757,057 imperial gallons; sulphate of ammonia 2,465,995 pounds; benzol, 121,734 gallons; gas, 1,203,954 cubic feet. No definite figures for 1921 are yet available, but it is believed that the coke production for this year will be equal to that of 1920.

TRADE NOTES

The Homestead Sales Corporation, 242 Lafayette Street, New York City, has been appointed sole agent for New York and vicinity by the General Specialty Company of Buffalo, N. Y., in the sale of their Torpedo Tube Cleaner and other boiler cleaning specialties.

The Orton & Steinbrenner Co. of Chicago, manufactures locomotive cranes, clam shell and orange peel buckets, have made arrangements with the F. C. Richmond Machinery Co., 117 West Second Street, Salt Lake City, Utah, to represent them.

The Philadelphia office of the Hauck Manufacturing Company, manufacturers of portable oil burners, torches, furnaces, etc., has been moved to 1726 Sansom Street. Bell 'Phone, Spruce 5626.

Stone & Webster, Inc., of Boston, have awarded a contract to The U. G. I. Contracting Company, of Philadelphia, for the installation of two 11' sets of carburetted water gas apparatus at the plant of the Fall River (Mass.) Gas Works Company. These sets will be of the U. G. I. cone top type, hydraulically equipped and will have the other modern appurtenances usual to U. G. I. apparatus.

The Rathbun Jones Engineering Company, Toledo, Ohio, has appointed the Ingersoll-Rand Company, New York, General Sales Agent for Rathbun Gas Engines. The large sales organization and service department of the Ingersoll-Rand Company, combined with the fact that gas engines are used to drive compressors, pumps and other machinery which it manufactures, places it in a position to serve better the users of gas engines and other machinery.

The Skinner Engine Co. of Erie Pa. has appointed Andrews-Bradshaw Co., 812 B. F. Jones Building, Pittsburgh, Pa., as their representatives in the Pittsburgh district.

The Koppers Company has been awarded a contract for a "Koppers Liquid Purification Plant" by the Battle Creek Gas Company of Battle Creek, Michigan. This plant will have a daily capacity for handling 2,000,000 feet of gas per day. A plant of this type has been in operation for over a year at Seaboard By-Product Coke Company's Plant at Jersey City, N. J., handling the entire gas output of that company, amounting to over 25,000,000 feet of gas per day. This method of gas purification has aroused a great deal of interest in the gas industry and was fully described in a paper read before the last meeting of the American Gas Association in Chicago.

The George J. Hagan Company have recently opened up offices in Detroit and Chicago. The Detroit office is located at 515 Murphy Building and is under the management of Mr. J. Sandberg, formerly of the General Electric Co. The Chicago office is located at 20 E. Jackson Boulevard and is under the management of Mr. V. A. Hain, formerly of the General Electric Co.

The Hardinge Company announces the acquirement of the Coal Washing Equipment as formerly supplied by the Coal Washing Equipment Co. of Pottsville, Pa. The equipment consists mainly of the James Automatic Balanced Jig, a device which has been developed and installed in a number of anthracite and bituminous collieries for reducing the sulphur and non-combustible content of coals ranging in sizes from ¼ in. to 4 in.

The Wilson Welder & Metals Company, Inc., 132 King Street, New York, N. Y., manufacturers of Arc Welding Machines and Certified Welding Metals announces the appointment of Mr. R. L. White as District Manager in charge of Detroit Office, 809 Kresge Building, Detroit, Michigan.

The Bario Metals Corporation of New York City will commence at once the installation of a new Alloy Melting Department including the installation of Four (4) Electric Melting Furnaces. The contract for the complete melting department has been awarded to F. J. Ryan & Company (Industrial Furnace Engineers), Wesley Building, Philadelphia, Pa.

Mr. C. L. Dewey, who was associated with Mr. Carl Akeley in the invention and development of the Cement-Gun, and who has done extensive Cement-Gun contract work under the names of the Dewey Cement-Gun Company and the Traylor-Dewey Contracting Co. of Allentown, Pa., has joined the forces of the Cement-Gun Construction Co. of Chicago, Ill.

TRADE PUBLICATIONS

The Treadwell Engineering Company of Easton, Pa., have issued a new catalogue illustrating and describing their "Stoever" line of Pipe Machines. These machines are used for cutting and threading steel and wrought iron pipe. For those engaged in this sort of work, this catalogue will prove very interesting.

The Deschanel Engineering Corporation of New York have just issued "Deschanel Cableway Bulletin," which describes their single line cable way used for material handling purposes. It will be sent upon request.

The Alabama Company, Birmingham, have issued an attractive booklet in reference to their machine cast pig iron. This method of handling pig iron is new in the south; this company being the only one to produce foundry iron in this way.

The Blaw Knox Company have issued a circular on Knox Patented Damper Type Water Cooled Reversing Valves. Many of these valves are now in use in the steel plants.

The Uehling Instrument Company of New York have recently issued two bulletins which they say are the beginning of a series on Combustion and the Cost of Power. The first, No. 220, is entitled "Magnitude of the Power Plant's Chimney Loss" and considers the importance of the loss through excess air. An interesting diagram is given showing the relative amounts of CO_2, excess air, and heat loss. It emphasizes the importance of apparatus for indicating and recording this condition. No. 221 is entitled "Relation Between CO_2 and Money Wasted up the Chimney." It contains a number of interesting tables and diagrams illustrating the money to be saved by increasing the percentage of CO_2 in the flue gas.

A new recording thermometer is described in an 8-page folder recently issued by the American Steam Gauge & Valve Mfg. Co. of Boston, Mass. This recorder is actuated by different methods, saturated vapor expansion, inert gas, or other liquids, depending on the purpose for which it is to be used.

"Water Tube Boilers" is the title of a new catalog recently issued by the Springfield Boiler Co., Springfield, Ill. It describes the equipment manufactured by this company and the advantages of it. The catalog is very well printed and shows to good advantage the numerous illustrations of the Springfield boiler applied to furnaces, both in the form of halftones and line cuts of blue prints. 24 pages and cover, size 8½x11.

The Mines Branch of the Canadian Department of Mines has recently published their Bulletin No. 564 on the "Preparation, Transportation, and Combustion of Powdered Coal" by John Blizard. This considers the various phases of the subject, the makes of equipment available, the results which have been obtained.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., APRIL, 1922 No. 4

Present Day Iron Blast Furnace Practice

The Metallurgist Rather Than the Engineer Is Now the Man on Whom the Present and Future Progress in Iron Blast Furnace Practice Depends.

By RALPH H. SWEETSER
Asst. to the Vice President, American Rolling Mill Co., Columbus, Ohio

THE present state of iron blast furnace practice is metallurgical rather than mechanical; the tendency is toward intensity rather than toward extension. The engineers have built blast furnaces big enough and strong enough, and have furnished accessory equipment ample and accurate enough for the present state of the art, but the metallurgical side has been too much neglected; the metallurgist, rather than the engineer, is now the man on whom the present and future progess in iron blast furnace practice depends. The mining engineer has produced great tonnages of iron ores, and has kept ahead of the demands for quantity; now the metallurgist is improving the chemical and physical qualities of this product by ore-dressing and other forms of beneficiation. For a generation or more. the principles of mechanics have had most influence in the advancement of iron blast furnace practice; attention now is given more to the principles of metallurgy, chemistry, and ore-dressing.

This metallurgical progress is taking place inside and outside the blast furnace. The two great determining factors of the inside operation are the slag, and the rate of combustibility of the coke. Outside the furnace, the progress is, and will be, along the lines of more careful mixing of ores and iron bearing materials, in the sizing and washing of limestone, and in the character and structure of by-product coke.

Blast Furnace Slags.

There have been almost as many theories on blast furnace slags as there have been blast furnace superintendents; and many of the theories were wrong, including my own.

During the war several important articles on blast furnace slag were published, perhaps the most notable paper being the one by Alexander F. Feild and P. H. Royster.† This article did not at the time receive the attention and discussion it deserved. Blast furnace men for the most part were concerned in keeping their plants in operation so as to produce the greatest possible tonnage, and there was practically no time for technical discussion. The paper, however, was of the utmost importance and brought out some facts contrary to the general opinion of blast furnace superintendents. These facts are now receiving more attention and the information developed, and since proved, is being used in burdening the furnaces. Mr. Feild and those discussing his paper pointed to the fact that the information obtained by the use of pyrometers in determining the melting points of slag had helped to remove "another element of uncertainty from the problems encountered in practice." On the other hand, this same paper had some imaginings that did not sound at all practical, though it might be hard to disprove them.

Investigations are being carried on to determine the value of certain slags with special reference to the effect on the blast pressure and the general working of the furnace. The development of the investigations of the Bureau of Mines and of individual blast furnace men have upset many of the preconceived notions regarding the causes of blast pressure inside the furnace. Further investigations are necessary to demonstrate fully the relation between the composition of the blast furnace slag and "the sticking and slipping" of furnaces.

Slag Disposal.

The demand for crushed slag as an aggregate in concrete work has increased in recent years, and much blast furnace slag now goes to the crushing and screening plants. Dry pits and steam shovels are generally used. Where granulating pits are still in use, it is usual to throw the wet slag into piles in freezing weather so as to drain off as much water as possible before loading it into railroad cars.

Fluxes.

More attention is now being given to the question of blast furnace fluxes than was formerly considered necessary. As a rule, the limestone for blast furnace flux was chosen on the basis of cost and freight rather than quality, providing the carbonates of lime and magnesium made up about 95 per cent of the stone. Open hearth slag is being more commonly used, especially where the blast furnace is a part of the steel plant. This is an economical way to dispose of the slag from the open hearth, and it is a double source of metal and flux for the blast furnace. In some cases the amount used is 10 per cent of the total ore burden.

Magnesia is still a subject of controversy, but Mr. Feild's statement‡ that "Magnesia (MgO), as such, does not affect the slag viscosity so far as practical pur-

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*Reprinted from March issue of *Mining and Metallurgy.*

†Slag Viscosity Tables for Blast Furnace Work. Abstract in *Trans.* (1918) 58, 650. Complete paper published by Bureau of Mines as *Tech. Paper* 187.

‡*Op. cit.*

poses are concerned unless present in amounts greater than 8 per cent," is being more generally believed.

The size of the flux stone still varies greatly in the different iron making districts, and in many cases the run of the quarry crusher is accepted providing the fine dust is screened out. It is generally conceded that a closer sizing of the flux stone is beneficial; and where "ballast size" stone has been used there has been some improvement in the working of the furnace. At a few large quarries the stone is washed after crushing.

Coke.

"Poor coke" has been the excuse of many a blast furnace superintendent for the poor work of his furnace, and no doubt the poor coke deserved much of the blame; but, what is poor coke? The Coke Committee (Committee D-6) of the American Society for Testing Materials is even sending out questionnaires asking "What is coke?" Some of the poorest looking coke, judging by the old standards of luster, "longer fingers," and "metallic ring," now gives the best results in the blast furnace.

Exact specifications for a good blast furnace coke have not yet been generally accepted, but efforts are being made to find standard tests for determining the value of by-product cokes. The rate of combustibility has been brought forward by Herman Brassert and others as one of the determining factors of the value of a coke. Resistance to breakage is another quality that is desirable, for which a proper comparative test is being sought. Much valuable work in this direction is being carried on by J. C. Barrett, at the Ohio works, in his tumbling-barrel tests.

It is claimed that if the blast furnace men can specify a certain rate of combustibility, and a certain toughness of structure, it will be possible for the by-product coke oven man to produce the desired coke by carefully mixing the coals for the ovens.

There is need for much research work to determine the proper structure and size of cokes, and to find the right descriptive terms for the relative values of the different cokes.

Standardization.

The indictment brought against "the management" in general, in reference to the responsibility for the excessive waste in industry, has been well deserved by the management of most blast furnaces. Until recently there was not even an approximate rule for determining the tonnage that should be produced by a blast furnace of a given size. In many cases the coke per ton of pig iron at one furnace was compared with the coke per ton of iron at other furnaces without any reference to the quality of the cokes used or to their contents of fixed carbon.

The rule for rating the capacities of blast furnaces adopted by the Southern Ohio Pig Iron and Coke Association (published in the trade journals) is based on the burning of a certain amount of a "base" coke in a given time (60 lb. coke per cu. ft. of working volume in 24 hr.). Starting with the idea that there is a definite rate of combustibility for a standard coke, assuming that the ore mixture contains 51.50 per cent iron in the natural state, and arbitrarily using 1,800 lb. of coke per ton of basic pig iron when the fixed carbon in the coke is 90 per cent, it is a simple process to determine what any blast furnace should make under varying conditions of coke, ore mixture, and percentage of silicon in the pig iron.

The general acceptance of a standard coke is the next step in the advancement of blast furnace practice. The United States Bureau of Mines, the American Society for Testing Materials, and other associations are trying to solve this problem.

In the operation of blast furnaces, especially at plants that began when all the pig iron was handled by man power and all the raw material was hauled in buggies, there has been too great a delay in getting rid of old customs and wasteful practices. Many of us can remember when blast furnaces 85 ft. high would have cover plates over the whole length of the casting trough at casting time. Even after the adoption of tap-hole guns, and electric drills for the iron notch, and casting machines in place of pig beds, there was a tendency to retain men in the cast house in greater numbers than needed. This was because there was no accepted standard for a day's work around the blast furnace. The adoption of these standards may seem to work hardships, especially in times of unemployment, but it is the only course to take if management is to get rid of the stigma of wasteful practices.

Beneficiation of Ores.

The physical qualities of iron ores are being improved by all the old methods of washing and roasting brought up to date, such as sizing (and crushing where necessary), washing, drying, nodulizing, sintering, and magnetic concentration. The sintering process has found extensive use in changing flue dust into a desirable blast furnace raw material; it is also successfully used in preparing fine magnetic concentrates for blast furnace use; in some instances the sintering process is used instead of roasting for the removal of sulphur.

Cost Accounting.

Great progress in blast furnace practice was made by the adoption of the Croxton Efficiency System with its uniform method of cost accounting. However, this method allowed only a comparison between one month's cost and another, or else only between the cost at one furnace and the cost at another. The only true comparison is between the actual cost for a given month and the standard cost for that month at that particular furnace. Such a comparative cost system has already been put into use.

The pig iron cost sheet at most blast furnace plants has been used almost exclusively as a guide for the sales department, and it has seldom been used in its other and more important function, as a guide for the successful operation of the blast furnace itself. Such a cost sheet, in order to be of full value to the furnace superintendent, must be promptly available and approximately accurate. When the actual amounts of ore, coke, limestone, labor and supplies, and the actual costs per ton of pig iron for these items, are compared with the ideal cost for that month, using standard amounts of materials and labor at the actual prices and wages, then, and then only, is a comparison made that is fair to the management, to the superintendent, and to the furnace.

In spite of the increased cost for freight in assembling raw materials for making pig, the location for new furnaces seems to be governed more by the market for the iron than by the location of any of the raw materials.

Electric Motors in the Steel Plant

Electric Motor Braking as Applied in a Steel Plant to Restrict Speed of Overhauling Load, to Cause Definite Slow Down and to Stop.

By GORDON FOX*

PART II.

DYNAMIC braking is sometimes employed in railway service and elsewhere, either with or without intent, through the action of two series motors, connected in parallel. Under certain conditions such motors will act in series to set up a braking current through their local circuit. This action may be best considered with the aid of the simplified diagrams in Fig. 5 a.b.c. Fig. 5a shows two series motors in railway service, connected in series. The arrows indicate the direction of current flow and armature counter-voltage. If the reverse switch be thrown and the main drum turned to a parallel position, the conditions are as shown in Fig. 5b. This is but a momentary condition, however. Due to the slight inherent differences which always exist between any two motors of the same design, one motor will have a higher residual magnetism than the other. This motor (A) will build up voltage more rapidly than the other (B). It will then tend to circulate current through motor B, overcoming the residual voltage of the latter and will reverse the field and consequently the voltage generated by Motor B. A local current then flows, as indicated in Fig. 5c. This braking current, flowing through the two motors in series, short circuited, is likely to reach severe values and may result in flashing or damage due to the mechanical shock of the sudden torque. This procedure should therefore be restricted, in railway service, to emergency condition. However, this condition may and sometimes does arise in other applications where two motors are paralleled, using a single set of starting resistors. Where two sets of starting resistors are employed, one for each motor, as indicated in Fig. 6, the local series circuit includes the starting resistors which suffice to prevent or restrict the flow of current in this local circuit. It is possible to prevent the flow of circulating current in a closed loop caused by reversing two series motors connected in parallel by interchanging the series fields, as indicated in Fig. 7. With this arrangement any unbalancing is quickly corrected. Sometimes an equalizer connection is used, connecting the armature-series field junction points of the two motors, for like purpose. This arrangement is indicated in Fig. 8. It is simpler than that of Fig. 7 but not so positive in corrective action.

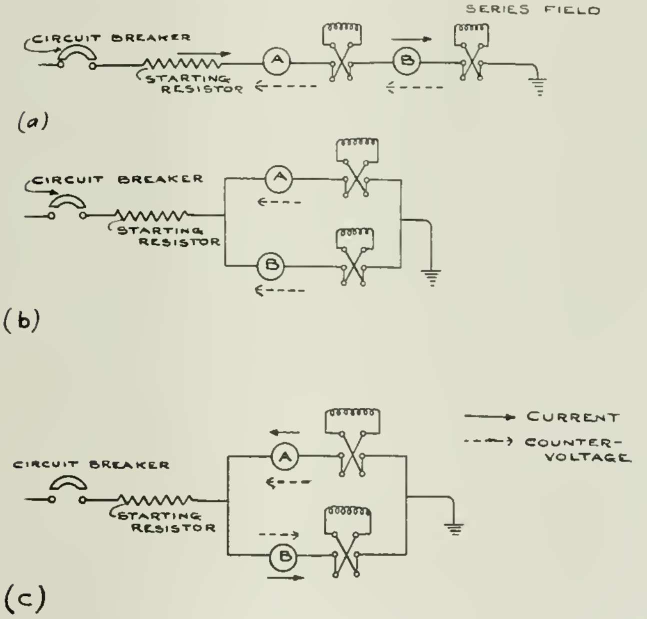

Fig. 5—Connections showing "bucking" of two series motors connected in parallel.

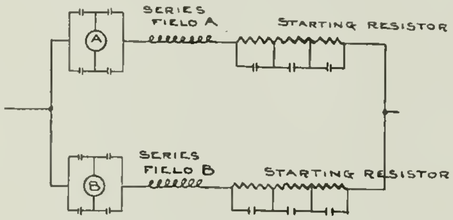

Fig. 6—Two series motors in parallel provided with separate resistors.

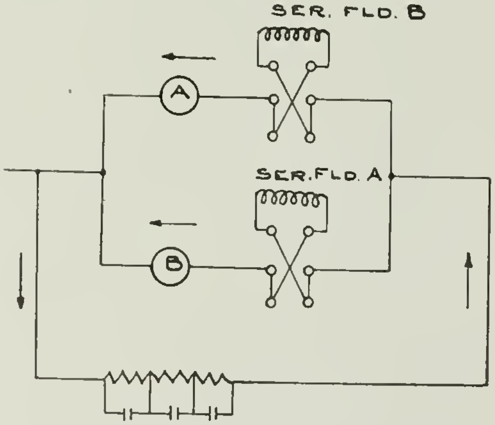

Fig. 7—Arrangement used in railway service for electric rheostatic braking. The series fields of the two motors are interchanged when reversed.

The alternating current induction motor is not inherently adapted for dynamic braking service. The load current and magnetizing current flow through the same winding and from a common source, and cannot be dissociated. Two schemes have been developed and applied for obtaining dynamic braking from induction motors. In both schemes direct current is applied to the primary winding to create a fixed magnetic field. The rotor conductors, cutting this field, generate voltage and circulate current in their secondary circuit. The braking torque may be governed by the amount of direct current in the primary and by the resistance of the secondary circuit. The amount of direct current introduced into the primary is in general magnitude comparable with the full load alternating current. The direct current supply must be at low voltage because only the resistance of the primary windings is involved. In one scheme the direct current is obtained from a small motor generator set which, in turn is excited from an auxiliary exciter. In another scheme the direct current is obtained from a generator which is mounted on a common shaft with the induction motor. This unit has its field winding excited from a tungar rectifier. The latter scheme offers some advantage in that the auxiliary dc. unit assists in braking, the braking current is automatically adapted to the load and the direct current excitation automatically ceases when the motor stops. The principal connections for these two systems of braking are shown in Figs. 9 and 10.

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*Electrical Engineer, Freyn Brassert & Co.

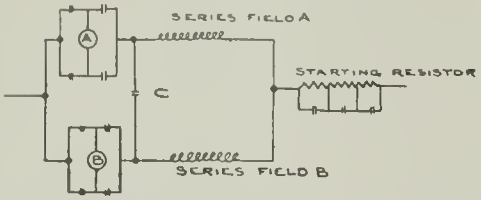

Fig. 8—Two series motors in parallel provided with equalizing connection. Contactor "C" open while motoring and closed while braking.

It is possible to obtain dynamic braking with the synchronous motor. This is accomplished by disconnecting the primary leads from the line, while the motor is running, and then short circuiting the primary through suitable resistance. The excitation of the field poles is maintained, at least in part. The rotating flux generates voltage in the primary, resulting in a braking current flowing through the primary windings and the external short circuiting resistance. This arrangement has been used effectively in the rubber mill for obtaining a very quick emergency stop.

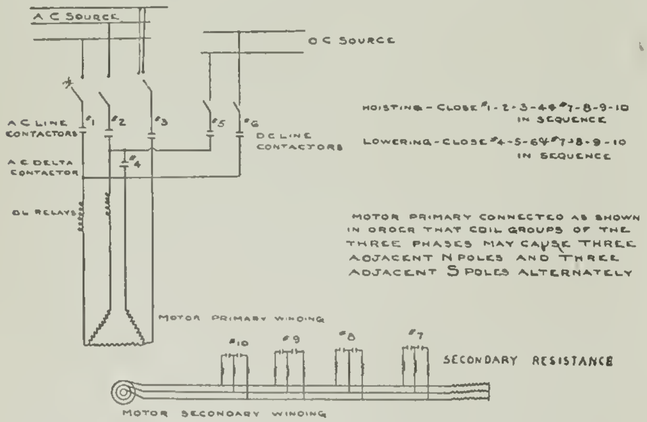
A C SOURCE
D C SOURCE
A C LINE CONTACTORS
#1
#2
#3
#5
#6
D C LINE CONTACTORS
A C DELTA CONTACTOR
#4
OL RELAYS
HOISTING - CLOSE #1-2-3-4 & #7-8-9-10 IN SEQUENCE
LOWERING - CLOSE #4-5-6 & #7-8-9-10 IN SEQUENCE
MOTOR PRIMARY CONNECTED AS SHOWN IN ORDER THAT COIL GROUPS OF THE THREE PHASES MAY CAUSE THREE ADJACENT N POLES AND THREE ADJACENT S POLES ALTERNATELY
MOTOR PRIMARY WINDING
#10
#9
#8
#7
SECONDARY RESISTANCE
MOTOR SECONDARY WINDING

Fig. 9—Dynamic Braking with induction motor.

If a direct current motor, running at full speed, have its starting resistance suddenly inserted in circuit there will be little or no electrical braking effect. The driving torque, will, of course, fall off and friction or load will slow down the machine, opposed by inertia. In case the load is overhauling the motor will speed up. Dynamic braking can be employed to obtain a definite slow down from full speed to a fixed lower speed, by connecting resistance in parallel with the armature, which is connected in series with the starting resistance. The voltage drop in the series resistance reduces the voltage at the motor terminals to a value lower than its countervoltage. Current is then forced by the armature through the parallel resistance in a direction to cause braking action until the armature slows down and the countervoltage drops off. The motor will quickly come to a speed corresponding to the reduced terminal voltage, the exact speed depending upon the values of series and parallel resistance and upon the load.

This action is obtained, with a shunt wound motor, by shunting the armature with the parallel resistance. With a series motor, the armature may be shunted by the resistance or the entire motor may be shunted, see Figs. 11 and 12. Shunting the armature alone causes a more pronounced braking action as the series field flux is well maintained or may be strengthened (depending on relative resistance values). Shunting the entire motor causes a less severe and less effective braking action. The low speed obtained with shunted armature is fairly constant, with either shunt or series motor but falls off somewhat under load. The regulation depends upon the series and shunt resistance values. Fig. 13 shows the speed current curves for a skip hoist motor, compound wound. Two slow down points are shown. The motor is a simple shunt motor while running, having the characteristic curve No. 1. On the first slow down point the series field winding is introduced, the starting resistance connected in series and the armature shunted with resistance. On

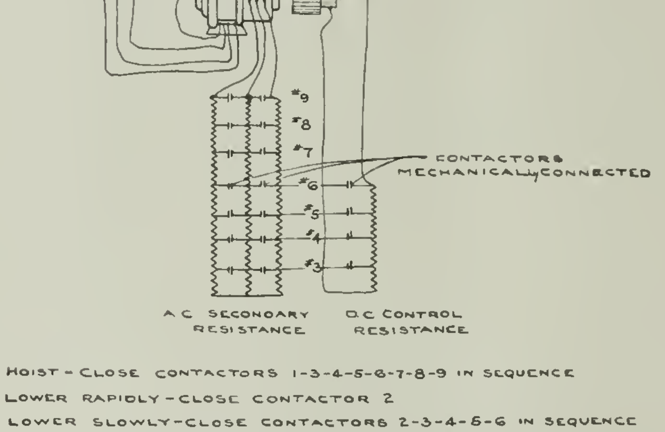
#1
#2
TUNGAR RECTIFIER TO SUPPLEMENT RESIDUAL
SERIES FIELD
A C MOTOR
D C ARMATURE
#9
#8
#7
#6
#5
#4
#3
CONTACTORS MECHANICALLY CONNECTED
A C SECONDARY RESISTANCE
D C CONTROL RESISTANCE
HOIST - CLOSE CONTACTORS 1-3-4-5-6-7-8-9 IN SEQUENCE
LOWER RAPIDLY - CLOSE CONTACTOR 2
LOWER SLOWLY - CLOSE CONTACTORS 2-3-4-5-6 IN SEQUENCE

Fig. 10—Principal connections of dynamic braking control with induction motor direct connected dc generator.

the second slow down point the shunting resistance is reduced. It should be noted that, if complete slow down were attempted in one step, there would be a very high initial rush of braking current, corresponding to full speed (300 rpm) on curve No. 3 and braking would be severe. It should also be noted that the torque developed on the slow speed points is relatively low and the motor may stall if the armature is too heavily shunted.

The wound rotor induction motor is similar to the direct current motor in that a definite slow down cannot be obtained by insertion of resistance in either primary or secondary circuits. A slower speed will eventually result but will not be attained through any marked braking action developed by the motor. The multispeed induction motor is applied, however, to obtain a definite slow down. The motor is run on its high speed winding, the low speed winding being utilized for the slow speed. At the instant of change over, the rotor is revolving at a speed exceeding the synchronous speed for the low speed winding. The motor acts temporarily as an induction generator with reversed torque. The action may be more evident by inspection of the curves in Fig. 14. It will be noted that the braking current at the instant of change over may be very high. In some cases external resistance is inserted in the secondary circuit of a wound rotor motor to minimize this effect. In some cases a high resistance cage motor is employed. This has a less flat characteristic and the current inrush is lower. Primary resistance is also used with some cage motors.

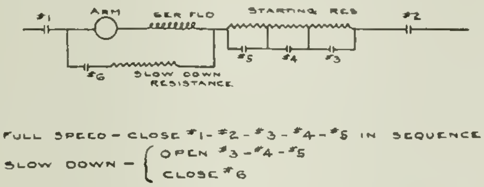
#1
Arm
Ser Fld
Starting Res
#2
#5
#4
#3
#6
Slow down resistance
Full speed – close #1-#2-#3-#4-#5 in sequence
Slow down – open #3-#4-#5
close #6

Fig. 11.

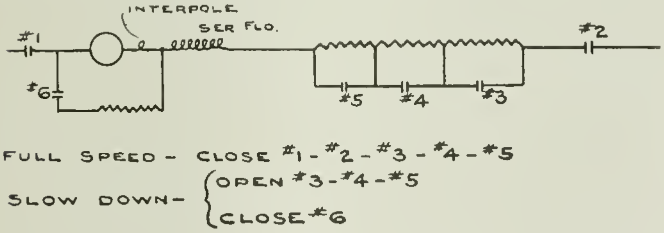

Fig. 12.

A somewhat special case of dynamic braking is employed in crane hoist service. The direct current series motor is most commonly used. When lowering a light hook, it is necessary that the motor drive downwards as the weight is usually insufficient to overcome the friction of the hoist. In lowering heavy loads, the motor must retard. This double duty is accomplished by connecting the motor as a shunt machine by placing the series fields across the line in series with resistance. The armature is also connected across the line, in series with other resistance as shown in Fig. 15. The solid arrows show the direction of current flow when the motor is driving down a light hook. The dotted arrows show the flow of retarding current. The latter may be largely or entirely confined to the local circuit comprising armature series fields and armature resistance. In some controls the line is disconnected after the load overhauls. It should be noted that the braking influence is adjustable and the lowering speed adjustable, depending upon the resistance in the armature and series field circuits. These resistances are varied on the different control points. Fig. 16 shows the characteristic curves for the various control points.

A word may be in order concerning the uses and advantages of dynamic braking. These have been already suggested. Perhaps the most extensive application is in crane and hoist service for lowering. Elevators employ dynamic braking both for slow down and for stopping. Skip hoist control uses it similarly. Machine tools use dynamic braking to obtain a quick stop. Some reversing planers use it to bring the plater to a stop prior to reversing. Dynamic braking is used extensively on steel mill auxiliary drives, such as the screw down, to obtain a quick stop. It is used on ore and coal bridges for lowering the bucket and also for stopping the man trolley. It is used on the ingot buggy to obtain a slow down. There are many other less general and less conspicuous applications.

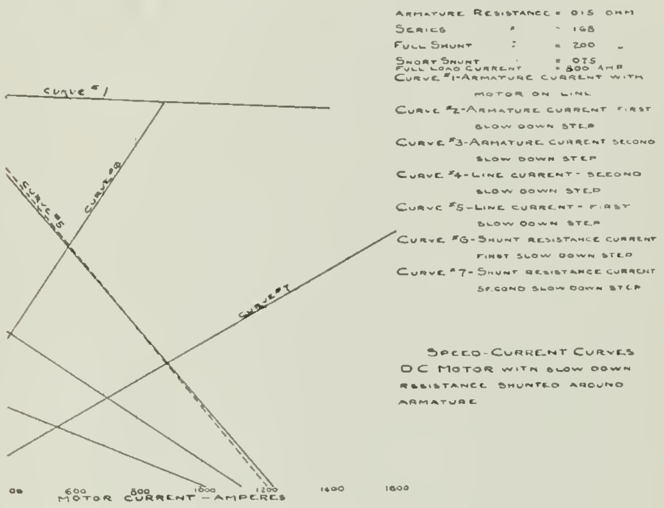

Fig. 13.

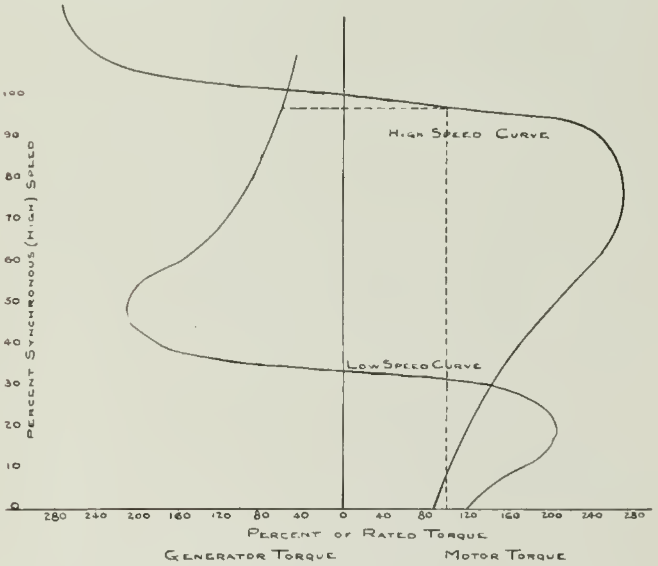

Fig. 14—Speed torque curve of two speed (3 to 1) induction motor.

The advantages of dynamic braking are many. It has proven superior to mechanical braking on cranes and hoists. The principal advantages, here as elsewhere, are the nicely graduated control and the freedom from mechanical maintenance. The upkeep of friction brakes used for retarding or stopping is likely to be difficult and expensive. With dynamic braking most of the heat is dissipated in resistors situated apart from the motor. A brake on the motor shaft may transmit heat to the motor to a serious extent. Dynamic braking is easily adjustable and maintains its adjustment. Friction brakes require frequent adjustment and are affected by water and oil. Dynamic braking is quicker in action as most brakes have an appreciable time lag. Dynamic braking is sometimes used and supplemented by mechanical brakes. The dynamic braking reduces the speed to a point where this method of braking becomes ineffective. The mechanical brake then stops the motor.

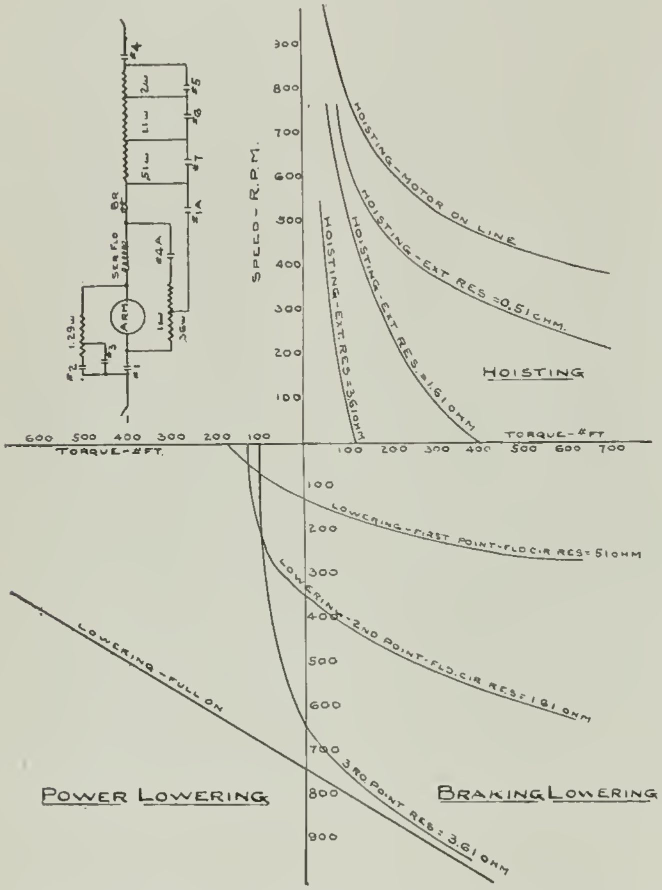

Fig. 16—Characteristic curves—dc series mill type motor with magnetic crane hoist controller. Showing action on various hoisting and lowering points.

This topic would not be complete without considering the work which must be done in stopping a motor and its driven load. When the driving power is removed and braking applied the inertia of the motor and moving machinery tends to continue the motion. It is necessary, in braking, to dissipate the kinetic energy stored in these parts.

The energy stored in the motor armature or rotor is E_A

$$E_A = \frac{Wr^2 \times RPM_A^2}{5870} \text{ ft. lbs.}$$

Where Wr^2 = moment of inertia of the armature, weight × radius of gyration ^{2}.

RPM_A = rotative speed of armature.

The energy stored in the rotating machine parts computed at any selected shaft is E_m

$$E_m = \frac{W_m R_m^2 \times RPM_m^2}{5870} \text{ ft. lbs.}$$

Where W_m = weight of revolving members—lbs.
R_m = radius of gyration revolving members—ft.
RPM_m = rev. per min. of selected shaft.

The energy stored in parts having linear movement may be determined by considering same as concentrated at wheel rim or drum periphery, as the case may be, or by considering linear forces. For instance, in a hoist, the energy stored in the moving suspended load is E_H.

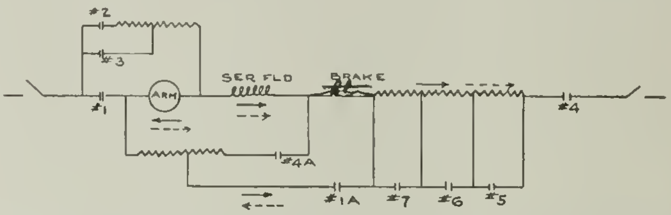

Fig. 15—Diagram of principle connections. Direct current crane hoist control. Solid lines indicate current flow when driving downward. Dotted lines indicate current flow when restraining overhauling load.

$$E_H = \frac{W_H}{64.32} \times \left(\frac{V}{60}\right)^2 \text{ ft. lbs.}$$

Where W_H = weight of all parts in linear motion. Lbs.
V = linear velocity — ft. per min.

The work done by or against gravity on the unbalanced portion of the suspended load, as in the case of a hoist, is E_G.

$$E_G = \frac{W_u V_t}{120} \text{ ft. lbs.}$$

Where W_u = unbalanced weight — lbs.
$_t$ = time to stop — seconds.

The net or total energy of the load, to be absorbed by the motor or brake is E_N.

$$E_N = \frac{W_H V^2}{230{,}000} \pm \frac{W_u V_t}{120} \text{ ft. lbs.}$$

Use + for stop while lowering.

Use — for stop while hoisting.

This is in addition to the kinetic energy of the motor armature and revolving parts of the hoist.

TO ADVISE CHINA PROJECT

The Trumbull-Cliffs Furnace Company has retained Freyn, Brassert & Company, Chicago, in connection with extensions to electrical power output, at its blast furnaces at Warren, Ohio. The Chicago company also has been retained by the Kailan Mining administration, China, as consultants in concentration and mill tests on their low grade magnetic ores.

Efficient Arrangement of Open Hearth Labor

Reduction of Forces by Better Distribution of Men and Occupations in Operating a Modern Open Hearth Shop.

By P. S. YOUNG

THE reduction of forces in plant operation has always been and always will be an aim, as it reduces the cost of the product, the labor turnover, the expenses of timekeeping, and increases the amount which can be paid each man for his work. At this time it comprises one of the gravest issues in production topics, for several other reasons:

(1) As we come back to normalcy the prices of the product and of labor must come down, and yet production must be increased. To do this men must either work at a figure which will give them bare existence until the other fellow's goods come down to make the cost of living generally lower, or else the number of men to manufacture the product must be decreased thereby allowing a higher rate per man, but giving the product to the consumer at a cost which he will be able and willing to pay.

(2) The second reason seems more empirical but is none the less true. At the time of the last great business depression it was necessary to lay off practically all the less important employees of the Steel Mills. This of course occasioned great privation and suffering, which will not be quickly made up by work at a low rate as the men will have to apply all their earnings to the daily necessities while working for low pay and will be unable to make up for expenses incurred during their previous period of unemployment. Thus we see, that any steps taken by the employers to decrease the number of men necessary for each process of manufacture and tending to hold wages at their present rate without further reduction is most essential to those employed in the manufacture. Also, when the next cycle of business approaches a depression the number of men to be laid off will be less in each process. From one point of view it would appear that the smaller number of men employed in the manufacture of any product would tend to keep large numbers of the unemployed from regaining employment. This, however, is not true. As soon as the factories, mills and railroads begin turning out and carrying products in quantity, unemployment will vanish and in its stead will come an actual shortage of labor. In fact, this efficiency will rather tend to balance the shortage of labor in times of high speed manufacture with the lack of employment at the times of business depression.

Let us now look at an average Open Hearth force for a twelve 100-ton Furnace Plant. It will run about the following, beginning at the Metal Mixer and ending at the Stripper and Mold Yard:

Metal Mixer

1	Mixer Craneman, two turns	2
1	Mixer Boss, two turns	2
3	Helpers, two turns	6
1	Mixer Ladle Skuller, two turns	2
6	Total	12

Stock Yard

4	Stock Cranemen, two turns	8
1	Stocker Boss, two turns	2
8	Scrap and Metal Loaders, two turns	16
4	Ore and Limestone Loaders, two turns	8
1	Oil Man, two turns	2
1	Buggy Rrepairman, one turn	1
1	Buggy Repairman Helper, one turn	1
20	Total	38

Charging Floor

3	Cranemen, two turns	6
2	Melter Foremen, two turns	4
12	First Helpers, two turns	24
12	Second Helpers, two turns	24
12	Third Helpers, two turns	24
1	Metal Chaser, two turns	2
2	Weigh Ups, two turns	4
6	Pull Ups, two turns	12
2	Test Boys, two turns	4
52	Total	104

Pitside

3	Cranemen, two turns	6
1	Pit Boss, two turns	2
2	Steel Pourers, two turns	4
4	Steel Pourers Helpers, two turns	8
2	Platform Men, two turns	4
1	Ladle Liner, one turn	1
2	Ladle Liner Helpers, one turn	2
1	Stopper Setter, two turns	2
1	Stopper Setter Helper, two turns	2
1	Nozzle Setter, two turns	2
1	Nozzle Setter Helper, two turns	2
1	Steel Shipper, two turns	2
1	Ingot Scales Weigher, two turns	2
21	Total	39

Mould Yard and Stripper

2	Stripper Cranemen, two turns	4
1	Mold Yard Craneman, two turns	2
1	Mold Yard Boss, two turns	2
4	Mold Scrappers, two turns	8
8	Total	16

Mixing House

1	Foreman, two turns	2
1	Craneman, two turns	2
3	Pan Men, two turns	6
4	Dolomite Shovelers, two turns	8
1	Coal Drier, two turns	2
1	Stopper Maker, one turn	1
11	Total	21

Open Hearth General Labor Gang

1	Foreman, one turn	1
12	Laborers, one turn	12

Millwright Department

1	Millwright, two turns	2
1	Millwright Helper, two turns	2
2	Total	4

Electrical Department

1	Electrical Inspector, two turns.	2
2	Helpers, two turns	4
5	Total	6

Office

1	Superintendent, one turn	1
1	Assistant Superintendent, one turn	1
2	Clerks, one turn	2
1	Timekeeper, two turns	2

Thus we find a total of 259 men employed on two turns or 142 men on day turn and 117 men on night turn. This is about the number of men employed normally for a twelve furnace shop. Of course at times of furnace repairing the number is increased. Now in a twelve furnace shop there is one furnace off for repairs practically all the time, and if not it is usually because some furnaces are going bad before their allotted time, in which shop we will find several furnaces off at one time and all on at another. For the sake of consistent production this should be avoided as much as possible and an effort should be made when a furnace comes off out of its turn to assign it a new turn and try to hold the other furnaces scheduled to come off long enough to allow the new order of repairs to adjust matters. This condition is most pronounced in shops where the fuel used is more injurious to the brickwork or where such exceptional stress is laid on quantity production that the workmen fear no criticism as much as that on low production. As repair work on furnaces does not come under the head of steel production labor, and the reduction of the repairing force in number of men can not be well dealt with in this paper, we will not consider these as a part of our force in this discussion.

The reduction of the producing force of men can be met in two ways, by the installation of labor saving machinery, taking the dolomite gun as an example, and the well considered and carefully thought out rearrangement of occupations. The rearrangement of occupations is not with the idea of grinding more work out of each individual but (1) of filling in the unnecessary periods when on account of the spasmodic character of Open Hearth work certain of the workers are not only idle and resting but so idle that they become restless, (2) the interweaving of several occupations showing a saving on each, (3) better shop teamwork on all lines of work rather than the attitude of specialization, (4) and this results in a more easily controlled and more elastic organization. In regard to the idle time mentioned above, there is no doubt in the world that it exists and even to a point where it is detrimental to the organization. This appeared in many shops at the time of the great flu epidemic in the Fall of 1918. In spite of the fact that about half the workers were absent the steel companies kept up production at a greater than normal rate. In some shops, of course, where the numbers of employees absent were more than half of the shop organization, and those who were working were nursing sick members of their families at home or were just returned from an attack and still sick, there was a slackening of production, but not at all in a ratio to the absentees. And for some time after the epidemic it was quite noticeable that the morale of the organization was improved. This leads us to the conclusion that a reduction in the working force means a raising in the morale of an organization when judiciously employed toward that end. The various Safety Departments will readily back me up when I say that more accidents are caused when men are engaging in horseplay or sleeping than in the regular functioning of their duties. It is the idle periods which cause men to resort to horseplay, and sleeping is an invitation to the mischevious ones to play some practical joke on the drowsy partner, while for a short time after a man is aroused from sleep he is more inclined to make miscalculations and be the victim of accidents which could have been easily prevented were he in a normal state of senses. Likewise, given a man with a set piece of work to do like the watching of a furnace as the job of a first helper. No one would consider having a first helper turn his attention to any other work than that of watching his furnace and turning out his heat of steel. This man, too, is usually not of the makeup that will lend a hand to horseplay or will be found sleeping on the job. The responsibilities of his occupation and his usual maturity eliminate those factors. Nevertheless, such a man is effected by the general attitude of those round about him, whether it be one of idleness or industry. With the rest of the organization on their toes the first helper will increase in efficiency and will be more watchful of his bath and more rapid in his judgment. Better teamwork is assured by having the men acquainted with more than one line of work in case of a shortage of men for a short time the organization will be better able to close up the gap left by the absentees. In the minor occupations where the rearrangement of the men will take the greatest effect, the men will have more diversity of occupation and it is from these men that at a later date will be drawn the men for the higher and more specialized occupations. When men are loafing and are not engaged in horseplay they are reading, talking, or gossiping. If they are talking of their work they are accomplishing a great deal in their industrial education. It is far from time lost. This is their school, and this is their method of study. If a majority of their talk were upon these lines it would be a loss to divert them from it. But, alas, how much of the conversation is spent in topics of this kind? Much of the talk is in the nature of gossip, some more is the recital of grievances real or imagined, and a little, a very little, is worse. At a few places, especially if there is any industrial unrest in the air, the agitators of their fellow men have fine opportunities to question some and answer others more loyal to the company from which they are earning their daily bread, little portions of the shop become forums, and quite a deal of mischief can be hatched before the culprits are discovered. Men most readily magnify imagined wrongs when they are restless and idle. These are some of the reasons for which the rearrangement of work may be valuable to the organization.

Reduction in the Open Hearth Office.

Two clerks and one timekeeper are shown, besides the Superintendent and his Assistant. In regard to the two clerks, try one with certain of the charging records or steel records turned over to the weighmasters. Or, if a time clock can be introduced do away with the timekeeper and turn his work over to the clerks. With the time clocks their labor will not be found burdensome. The writer does not approve of the elimination of the Assistant Superintendent, if for no other reason than that someone must fill in during enforced absence of the Superintendent, and someone should be his understudy in case of his departure to other labors. Besides he should be the one to do the field work of the department, while the Superintendent should supervise everything, attend matters of furnace practice and construction, and determine the policies of the organization of his shop. The Superintendent should have time during his other work to discover and overcome any discrepances in his steel, any lowering of furnace or pouring practice, and any interdepartmental controversies. It goes without saying that he cannot rightly perform all these functions unless he has assistance from one who is directly under his command. No melter foreman can take the place of an Assistant Superintendent.

Reduction at the Metal Mixer.

This paper assumes that the ladles are skulled at the Mixer. If they are not, they are at least skulled under some crane. By the use of a ladle skulling stand and the proper lining and plastering of ladles, iron skulls may be easily removed. The ladle stand in thought is one which consists of two arms which may be strapped to the arms on the trunnion of the ladle. The ladle bottom lug is attached to the bottom lug of the ladle which is raised until the hook slips off, when the 1 ladle drops with a great force on the stand. When the skull is somewhat loosened in case of a stubborn skull (in an easy one it can be at once lifted out of the ladle) the straps are attached to the trunnion arm and the skull is pulled loose from the ladle lip. If the Ladle Skuller be eliminated, the three Mixer Helpers can take care of his work with a skulling stand. A time study should be made of the three Mixer Helpers to see if one of these cannot be eliminated.

Reduction in the Stock Yard.

Here again enters rather the reduction by labor saving machinery than by rearrangement of occupation. A trestle with bins for the limestone and ore charge is a well known but potent factor in the reduction of labor at this point. If this cannot be effected, the nearest approach is a trench on each side of the cars at the point in the Stock Yard in which can be set the charging boxes which receive these commodities. In plants where no account of some local condition or a reloading from stock piles, the limestone and ore are loaded in gondolas, the center of the car can be unloaded by shovel and hand and when the bottom shows, a large bucket with teeth will unload the remainder of the car. The use of the large 60 in. magnet for scrap should be universal. No smaller magnet can be just as good. Also in two plants the writer noted cars of ten per cent silicon and seventeen per cent ferro phosphorus being unloaded by hand into storage piles under the magnet cranes. In both cases he was told by the stocker boss that they could not be unloaded by magnet and in both cases when tried they were so unloaded. One would think that until these commodities had been found to be non-magnetic that the attempt would be made to unload them the easier way. By a study of your Stock Yard, unless it is very unusual, the number of scrap and metal loaders can be fixed at six, and if overhead loading can be arranged for commodities such as limestone and ore the men at the bins should be two. Just one word more on the Stock Yard. By no means cut the number of men to a point where it hurts. In no place can production be as quickly effected as in this yard. The delays in the Stock Yard are irretrievably lost. Time lost there can never be made up. The stock will not melt until it is in the furnace, and to disorganize the Stock Yard is to lower production. The Stock Yard has to adapt itself to changing conditions, from scrap that takes little labor to level to scrap that is awkward to level or does not pack well and all this change in the shifting of a few cars. Manv an Open Hearth record lies rotting in the Stock Yard because those in charge of the plant's operations could not see the necessity for a little good scrap mixed with the bad. And after the scrap is in the furnace the trouble is not ended. A furnace charged too slowly or with badly packing scrap is in an excellent way for a "sticker."

Reduction on the Charging Floor.

There can be no reduction among the Melter Foremen or the First Helpers. Two Melter Foremen at least are needed for twelve furnaces and in some shops three would be an advantage. Each of the First Helpers has his hands full if he takes the proper care of his furnace and the working of the heat. Nothing can be added to him even should a large part of each turn be spent in apparent idleness. Not so with the Second and Third Helpers. Their work does not entail the actual responsibility that the First Helper holds. I feel sure that some one will say that the Second Helper is responsible for the tapping hole. He should not be. The First Helper should be held responsible for every part of the furnace, and this responsibility should not stop at the floor. It should extend to the checkers. The writer believes that a combination of Second and Third Helper would be one very good way to rearrange the duties of each of these occupations. The furnaces could be divided into batteries of three each. For each of these batteries four men would be sufficient to do the work of the Second and Third Helpers. They would constitute a gang which would be used in both branches of work, and two of these gangs would make bottom after heat was tapped. Unless the pits of the furnace are of the deep variety, or unless some other condition is extremely bad either in the construction of the shop or the handling of such commodities as furnace additions and loam, dolomite, etc., we see no reason why this system would not work out. And in such cases surely the addition of another man to the gang would be sufficient, and would constitute some saving. The labor saving devices on the Open Hearth floor and Pitside are in such an advanced state that it is really getting to be a time when we can decrease the number of men in the Open Hearth operations at these points. Most Open Hearths employ boys as pullups. Some employ the First Helper as a pullup. That is not so good. In this case we take away the service of an experienced shoveler at the time when the heat is working, or if the First Helper does the shoveling and does not work his doors a great deal of heat which should be retained in the furnace is going out of the door. At best it is a bad makeshift. Why not employ men to do the pulling up and have them attend to the cleaning up of the shop, the carrying of tests to the laboratory, and perhaps the wheeling of the ladle additions if shop conditions are such that these cannot be handled by the cranes. In this way the small boy is eliminated from the shop both as a test boy and pullup, and most Open Hearth men will rejoice with me in the removal of the small boy both as a mischief maker, an unreliable adjunct, and as a butt for horseplay. The duties of the Metal Chaser may be filled by the Weighup with telephone connections to the Mixer from the Scales.

Reduction on the Pitside.

On the Pitside the changes cannot be so radical as on the Charging Floor. However, the Pit Boss and Shipper can be combined in most cases, and the shipping notices can be sent to the Pits by one of the platform men. The number of men on the Pitside is hardest of all to determine as so much depends on what quality of steel the Open Hearth is making, into molds capped or uncapped, or bottom or top poured ingots. The Pitside figured above is concerned with top pouring ingots which are capped. But in this case we believe that at least one man and more, probably two, can be eliminated from each of the two pouring gangs. We believe also that the inspection of the Pouring Platform should be rigidly kept up by the Pit Boss in the interests of safety, as the Pitside today stands as the great hazard in the Steel Plant. Not that the Ladle Liner has two helpers. If a lining pit were installed one helper would be enough as he could pass the brick to the liner standing in the ladle. Where no pit has been possible, the writer has found it convenient to use the liner and his helpers to make small patches in bulkheads where hot spots appeared and to line spouts and even badly worn places in the charging floor.

Mold Yard and Stripper.

In the Mold Yard a great labor saver is an old cylinder with arms to hold the lugs of the mold. To the piston of the cylinder is attached a ram which pushes off the scrap from the mold. If a larger cylinder were to be so arranged and to have brackets as well as arms many mold stickers could be handled. In every Mold Yard there should be kept a supply of gas. This would be splendid when any of the buggies are badly gummed, and it could be used in combination with the ram for stickers. We feel that by this method at least one man could be easily spared from the Mold Yard.

Reduction in the Mixing House.

In one plant the Mixing House craneman is foreman of the operations. This is an excellent plan for that plant and I feel that it would work out well in most Mixing Houses. He is in direct view of the various parts of the Mixing House and from his post he can see well all operations. As he is in command, when he lowers the buckets into the wells or pits at the side of the cupolas the dolomite shovelers start to work at once. He brings the materials to the pan men, and he keeps in very close touch with his men. Where the coal drying is done in the Mixing House, the coal drier can be eliminated and his work done by the pan men.

Let us see what has been accomplished by these reductions. The force now stands:

Office

			Reduction.	(Both Turns)
1	Superintendent, one turn	1	..	.
1	Assistant Superintendent, one turn	1	..	..
1	Clerk, one turn	1	1	1
1	Timekeeper, one turn	1	..	..
4	Total	4	1	1

Metal Mixer

1	Mixer Craneman, two turns	2		
1	Mixer Boss, two turns	2		
3	Mixer Helpers, two turns	6		
.	Ladle Skuller or one Helper	..	1	2
5	Total	10	1	2

Stock Yard

4	Stock Cranemen, two turns	8		
1	Stocker Boss, two turns	2		
6	Scrap and Metal Loaders, two turns	12	2	4
2	Ore and Limestone Loaders, two turns	4	2	4
1	Oil Man, two turns	2		
1	Buggy Repairman, one turn	1		.
1	Buggy Repairman Helper, one turn	1	..	.
16	Total	30	4	8

Charging Floor

3	Cranemen, two turns	6		
2	Melter Foremen, two turns	4		.
12	First Helpers, two turns	24		..
16	Second-Third Helpers, two turns	32	8	16
2	Weighups, two turns	4	1	2
6	Pullups, two turns	12	2	4
41	Total	82	11	22

Pitside

3	Cranemen, two turns	6		..
1	Pit Boss, two turns	2		..
2	Steel Pourers, two turns	4		..
4	Steel Pourers Helpers, two turns	8	2	4
1	Ladle Liner, one turn	1	.	..
1	Ladle Liner Helper, one turn	1	1	1
1	Stopper Setter, two turns	2	.	..
1	Stopper Setter Helper, two turns	2	..	.
1	Nozzle Setter, two turns	2	..	.
1	Nozzle Setter Helper, two turns	2		..
..	Steel Shipper	..	1	2
1	Ingot Scales Weighup, two turns	2	..	..
17	Total	32	4	7

Mold Yard and Stripper

2	Stripper Cranemen, two turns	4		..
1	Mold Yard Craneman, two turns	2	.	
1	Mold Yard Boss, two turns	2	..	.
3	Mold Scrappers, two turns	6	1	2
7	Total	14	1	2

Mixing House

1	Foreman, two turns	2	.	..
..	Craneman	..	1	2
..	Coal Drier	..	1	2
3	Pan Men, two turns	6		..
4	Dolomite Shovelers, two turns	8		..
1	Stopper Maker, one turn	1		..
9	Total	17	2	4

Open Hearth General Labor Gang

1	Foreman, one turn	1	..	..
12	Laborers, one turn	12	..	..
13	Total	13	..	..

Millwright Department

1	Millwright, two turns	2		..
1	Millwright Helper, two turns	2		..
2	Total	4		..

Electrical Department

1	Electrical Inspector, two turns	2		.
2	Helpers, two turns	4	.	..
3	Total	6	..	..

Reductions by Departmental Units

		Both turns.
Office	1	1
Metal Mixer	1	2
Stock Yard	4	8
Charging Floor	11	22
Pitside	4	7
Mold Yard	1	2
Mixing House	2	4
Total Reductions	24	46

Time studies comprise an excellent way to find inefficient arrangement of men.

In making any cuts in force the following rules should apply:

1st. Will this cut injure the quality of my steel?

2nd. Will it injure my production?

3rd. Will it cause the remaining men in that occupation to work harder than I would be willing to work myself in their positions?

4th. Will the wages I will pay these men be commensurate with their increased efficiency?

If these questions can be satisfactorily answered, the issue should be fearlessly pressed.

Steel Company Completes New Additions

The Indiana Rolling Mill Company Makes Additions to Buildings and Equipment—Enlarged Plant to Follow These Improvements.

By A. C. GAYLORD*

THE close of the year 1921 saw the completion of improvements costing approximately $250,000 at the plant of the Indiana Rolling Mill Company, located at New Castle, Ind. Most of this amount was expended in the rolling mill department.

The company is engaged in the manufacture of two lines of goods, a complete line of shovels and spades and the rolling of high carbon sheet steel.

Most noticeable of these improvements is the new two-story and basement office building located on the hill about 500 feet west of the plant. It is built of reinforced concrete, seal brown Hitex brick, and mottled white and brown terra cotta for trimmings.

It is located high enough to overlook the entire plant and affords an interesting view of the Blue River Valley across to the city of New Castle.

The first floor of the office building is divided into a large general office, five private offices, a ladies' rest room, etc. Only part of the second floor is finished at present, providing one office and drafting room. The basement, which is well lighted, will be used for laboratory and cafeteria.

The power plant has been increased by the addition of a 550-hp. high pressure Springfield water tube boiler and a 1,000-hp. Murray Corliss engine. The boiler is equipped with an automatically controlled Riley stoker and a 6x135 ft. stack. This has been so located that it will be the first of a series of boilers in the completed design. The old boilers are of the Geary water tube type, hand fired and equipped with Coppus blowers.

The new boiler is enclosed in a temporary building, and the coal is delivered to the stoker hopper by means of a 25-ft. Unicon portable belt conveyor, so arranged that it can receive coal directly from the car or from the storage space in front of the boiler, within a radius of 30 ft. This coal elevator enables the fireman to unload the coal from the car into the hopper of the conveyor with less effort than is required to shovel the coal from the floor into the stoker hopper.

At present the ashes are removed from the ashpit by hand through a tunnel which also serves a gas producer and a Type E furnace stoker.

Plans have been made to erect a new boiler house large enough to accommodate at least two boilers which will be equipped with modern coal and ash handling machinery.

An extension, 120x120 ft., has been added to the main rolling mill building to provide space for the new 28-in. sheet mill. This addition consists of the main span 60 ft. wide and two lean-tos, 27 and 33 ft. wide, respectively. Two steel trusses are spaced 20 ft. centers and the supporting columns also carry the crane track girders. A new 15-ton Milwaukee crane, equipped with 5-ton auxiliary hoist, has been added to the old crane service.

Part of the floor space in this extension is covered with concrete, and a loading platform 26 ft. wide extends along one side of the building. The lighting facilities are excellent and good ventilation is secured by means of mechanically operated windows in monitors.

The 28-in. sheet mill was furnished by the Mesta Machine Company of Pittsburgh, Pa., and consists of herringbone reduction gears, 28-in. pinion stand, 28x48-in. roughing stand and two 28x36-in. finishing stands, one of which can be used as a reducing stand whenever necessary.

The reduction gears are cast steel and reduce the engine speed from 75 rpm to 40 rpm. for the speed of the rolls. The pinions are cast steel and the pinion housings are cast iron. The roughing stand housings are of cast steel and weigh 34,000 pounds each. The rolls are also cast steel. The upper roll is counterbalanced and the screws are operated by a 10-hp. motor. An ingenious steam operating lifting table passes the slab back over the top roll to the roller. The housings of the finishing stands are also of cast steel. The first of these is provided with a removable steam operating tilting table for use when reducing heavy stock, or when cogging down. One operator handles both tables at the same time.

A motor driven hot shear is used to cut up the slab before being passed to the finishing rolls. This shear can be moved to the delivery side of the reducing stand when the mill is used for cogging down purposes.

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*Mr. Gaylord is general superintendent of the Indiana Rolling Mill Company. He is also a member of The Society of Industrial Engineers.

The finished sheet is passed through a straightening machine, which reduces it to a perfectly flat sheet. The stock for this mill is heated in a continuous powdered coal burning furnace equipped with water cooled skids and hydraulic pusher. The coal is fed from a concrete hopper to a crusher by means of a screw feed. From the crusher it falls into the hopper of the elevator which carries it up and deposits it upon the belt of a magnetic separator which, after extracting "tramp iron," delivers it into a storage bin located over the pulverizer. An Aero pulverizer reduces the coal to the proper fineness and automatically mixes it with sufficient air to secure proper combustion. This mixture is fed into the combustion chamber through cast iron nozzles. These nozzles are provided with controlling valves and means for adding auxiliary air from a pressure blower. This air supply can be closely regulated and in the event of the pulverizer being shut down, can be used to keep the heat from entering the supply pipes.

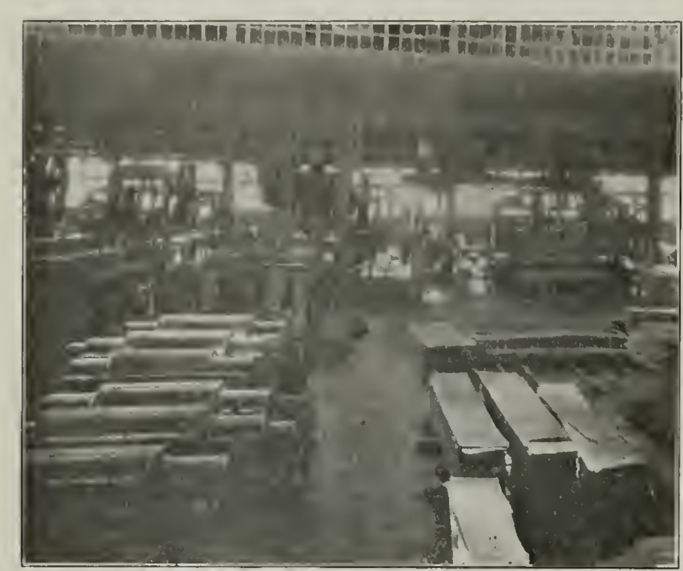

Fig. 1—Interior view of the finishing department.

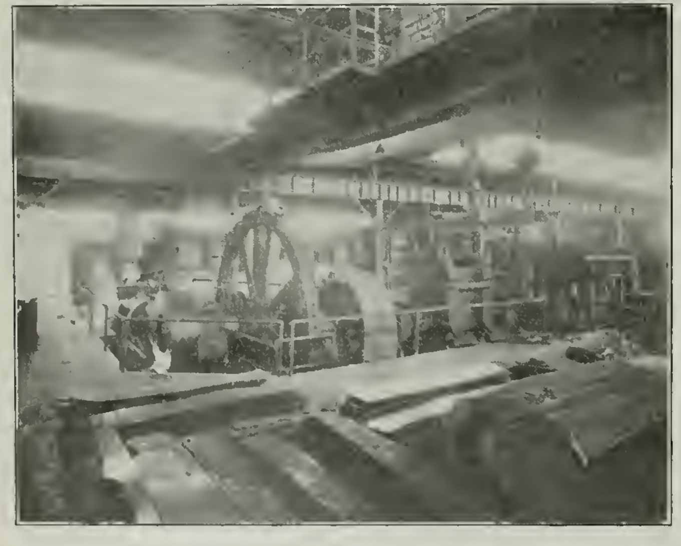

Fig. 2—View of the mill drive.

The old plate mill furnace was remodeled by making it continuous and equipped with a Type E stoker. Very satisfactory results have been obtained since this change was made.

The sheet mill powdered coal furnace has not been in operation long enough to secure comparative data as to the relative merits of the two methods of heating.

This new 28-in. sheet mill is driven by a 30x48-in. Murray Corliss engine, weighing 83,000 pounds exclusive of flywheel and out bearing, which were not furnished by the builders. The sectional flywheel weighs 50,000 pounds and is 20 ft. in diameter. The engine will deliver 940 hp. while operating under a steam pressure of 160 lbs. at one-fourth cut off and 75 rpm. It is equipped with a specially designed safety stop device, suitable for rolling mill service. This new equipment will enable the company to produce high carbon sheets more economically than was possible on the 22-in. mills. Approximately 50 carloads of sand and gravel, 15 carloads of cement and 10 carloads of brick were used in making these improvements.

A large electric caterpillar crane is used to unload slabs and load scrap. This is easily moved about the yard and has some advantages over the railroad type.

Stuebing lift trucks are used to handle and load the finished product. The floors in the shearing department are of concrete and the loading track is depressed sufficiently to allow trucks to enter the cars.

The shearing department is equipped with three 120-inch shears and three Toledo presses. One of the latter weighs over 80,000 pounds and is capable of punching out discs 32 in. in diameter. A number of smaller shears and punches are used in cutting up scrap and for light punching.

PRACTICAL USE OF THE OPTICAL PYROMETER.

The optical pyrometer depends upon the principle, that the brightness of the light-emission of a highly-heated body, bears a known proportion to the temperature of same. In practice, the light emitted, is observed through a filter, which only permits the passage of light of a certain wave-length, and this beam is compared with that of a filament lamp of known intensity. The brightness of radiation from the lamp is then regulated until it agrees with that emitted from the body under observation. The amount of such regulation shows the brightness of the body, and, with suitable corrections,a a close proximity to its temperature.

Optical pyrometers are of two kinds, broadly speaking. (1) The Wanner, using polarized light observed through a Nicol, by rotating which, the brightness can be altered, the amount of rotation necessary determining the relative brightness. (2) The Holborn-Kurlbaum, wherein the brightness of the filament lamp is altered by resistance. With this instrument, the strength of current necessary to produce brightness in the lamp, equal to that of the observed body, supplies the measure of relative brightness.

In the first case, one only sees the polarized light from the object under examination, but with the second instrument, the object itself, also the surroundings, are seen, but, owing to the telescope, reversed. At the same time, one also sees the glowing filament, the image of which is caused to fall upon the image of the body. The resistance is then regulated until the former merges indistinguishable into the latter, i. e., until the brightness of each is identical.

Recent Development In European By-Product Coking

A Series of Articles Dealing with the Various Types of Electric Gas Governors Which Have Been Introduced in Europe.

By A. THAW

PART II.

IN the first of my series of articles appearing in the March issue of THE BLAST FURNACE AND STEEL PLANT, the governor manufactured by Kress, a coke works manager, was described. We will follow up this month by describing the other principal styles of electric governors brought out in Europe during the past few years.

Governor by Allgemeine Vergasungs-Gesellschaft, Berlin.

This governor is shown in Fig. 5 diagrammatically. The receiver for the pressure variations consists of a single bell *a*, floating in a vessel partly filled with water or oil and connected by a steel band with counterweight to a shaft to which finger-like two contacts are fixed. The cables lead to the regulating device consisting of a mechanically operated magnetic reversing clutch *b*, driven by a little motor *m* running permanently in the same direction and connected by means of a worm gear to the butterfly valve *c* in the gas main, serving as a regulating medium.

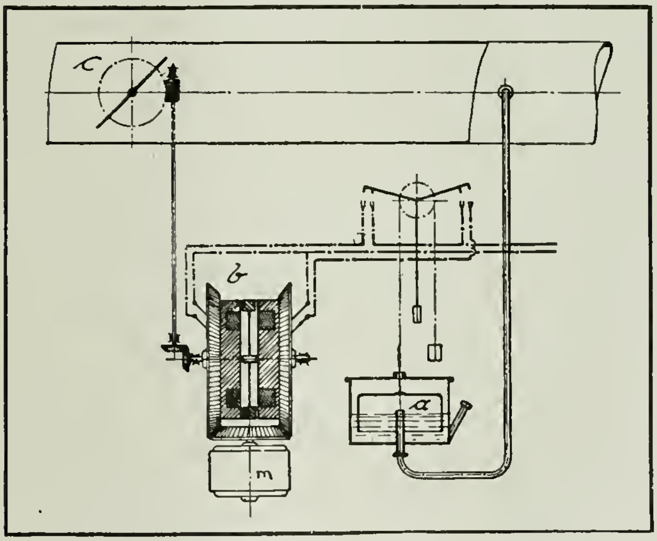

Fig. 5—Diagrammatical view of governor arrangement by Allgemeine Vergasungs-Gesellschaft of Berlin.

The motor is geared to the two bevel wheels of the clutch and turns them permanently in opposite direction to each other, loosely running on their shaft. The latter being on one end geared to the worm drive of the butterfly valve *c*, carries in the middle between the two bevel wheels a friction wheel fixed by a key to the shaft. The two loosely running bevel wheels are provided on their inside planes with electro magnets and depending upon which the gear wheel is turned a corresponding number of times and the valve *c* is adjusted accordingly. In a still later construction the magnets are carried by two wheels keyed to the shaft back to back, each facing one of the bevel wheels. While the arrangement is closely drawn together in Fig. 5, there may, of course, be an unlimited distance between the receiver and the adjusting device. The advantage of this arrangement compared with the former is obvious in that the movement stops immediately after the circuit is broken, as the speed of the reversing clutch is comparatively slow.

In all cases of butterfly valves being employed as a regulating medium for large diameter gas mains, the application of a worm gear becomes compulsory, as otherwise the flow of the gas will alter the position of the valve disc on its own account.

Governor by Reineke.

The latest design in this connection is the governor by Reineke, being shown diagrammatically in Fig. 6. The adjusting arrangement is influenced by two little motors of ¼-½ hp. each. They also operate a reversing gear which, however, does not act upon electromagnets, but works mechanically, its principle being based upon certain well known physical laws. The shafts of the motors I and II are rigidly connected to the two bevel wheels Z2 which are running loosely on the short shaft B. The latter is fixed to the ring A and this ring A is again fastened to the bevel wheel Z3, which can revolve freely on the shaft of the motor I. The bevel wheel Z3 is in gear with the bevel wheel Z3A, which is directly connected to the butterfly valve serving as a regulating medium.

The regulating action can be described as follows: The ac. motors I and II run normally at the same speed in opposite direction to each other, driving at the same time two bevel wheels Z2 which run in this case loosely on their shaft B without turning it. Thus the bevel wheel Z3 and at the same time the butterfly valve remain stationary. To move the latter in both directions, it becomes necessary that for a corresponding time the speed of the motors varies from each other and to cause the variations of gas pressure to effect this, a mercury contact arrangement is provided, influenced by a floating bell D connected to the gas main by a pipe. If, for instance, the gas pressure increases, the rotor resistance F remains short circuited while the contacts F1 leave the mercury, bringing the rotor resistance F1 into circuit so that the number of revolutions of the motor I becomes less than of motor II.

As now the number of revolutions of the bevel wheel on motor I is different to the bevel wheel driven by motor II, the bevel wheels Z2 are compelled to revolve not only around their own shaft, but also corresponding to the difference of revolutions with a certain speed and direction around the shaft of the bevel wheels Z1. If the gas pressure decreases and the contact lever C is lowered, dipping into the mercury contact, so is thereby the speed of the motor II reduced (motor I running normal) and the bevel wheels Z2 travel in opposite direction around the bevel wheels Z1 By means of this travel, the bevel wheel Z3 is turned and conseqently the butterfly valve is adjusted correspondingly and moved along until the gas pressure and the weight of the bell balance themselves again. The contact lever then remains in the horizontal position, as shown in Fig. 6, and both motors revolve at the same speed, both rotor circuits being short circuited. For adjusting the arrangement in any desired condition, the floating bell D carries a weight C consisting of a variable number of plates. On the opposite end of the contact lever C, a second float may be arranged as shown, serving as an air buffer by the space underneath this bell being connected to the atmosphere by means of a pipe with adjustable cock. This arrangement prevents an action of the apparatus in case of minute pressure waves. The governor by Reineke, though of quite recent design, has been adopted by a great number of works dealing with large volumes of gas and it has well justified its claims.

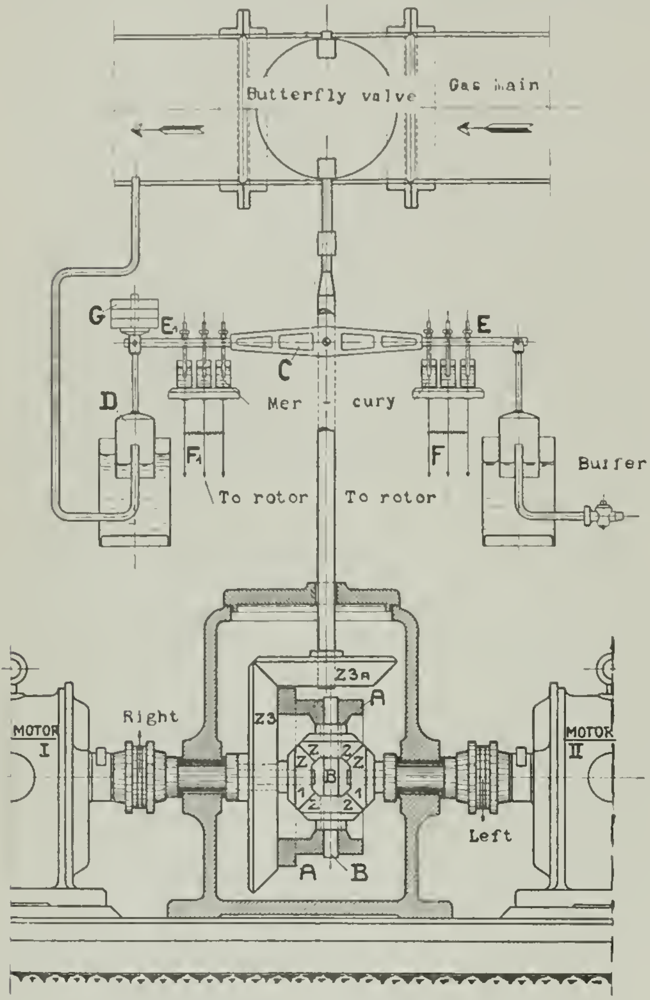

Fig. 6—Governor arrangement by Reineke.

Governor by Simon-Carves, Manchester.

Simon-Carves of Manchester, England, have brought out a new type of electric governor in which electromotors are altogether dispensed with. The arrangement is shown in the diagrammatical sketch in Fig. 7 and will be briefly described. A bell *a* floats in an oil seal *b* over the end of a branch *c* from the gas main *d*. The bell is connected to one arm *e*1 by a rocking lever *e* and the other arm *e*2 of the lever is connected to one terminal of a battery *f* and is adapted to co-act with a pair of contacts *g*, *h*, to complete the circuit through one or other of a pair of solenoids *j*, *k*, which are connected to the other terminal of the battery *f*, in parallel, and to the contacts *g*, *h*, respectively. The solenoids *j*, *k*, are provided with cores *j*1, *k*1, connected by wires *j*2, *k*2, to the arms of a double armed quadrant *m*, which in turn is connected by link *n* and lever *o* to a valve *p* situated in the passage *q* through which the gas is drawn off from the main *d* by the exhausters.

Normally the arm *e*2 of the lever *e* does not engage either of the contacts *g*, *h*, neither solenoid is energized, and the valve *p* is partially open to a predetermined extent. In the event of the generation of gas in the ovens and the pressure in the main *d* falling below normal, the bell *a* falls and rocks the lever *e* to cause the arm *e*2 to engage the contact *g* and close the circuit through the solenoid *j*. On the energizing of this solenoid its core *j*1 is pulled down and operates the quadrant *m* into the position indicated in dotted lines, which through the link *n* and the lever *o* partially closes the valve *p*, thus reducing the effective area of the passage *q*. If, on the other hand, the generation of gas and pressure in the main *d* should rise above the normal, the bell *a* rises and operates the rocking lever *e* so that its arm *e*2 engages the contact *h* and completes the circuit through the solenoid *k*. The core *k*1 of this solenoid is then pulled down and operates the quadrant *m* into the position indicated in dotted lines to further open the valve *p*, to increase the effective area of the passage *q* until the pressure in the main again reaches the normal.

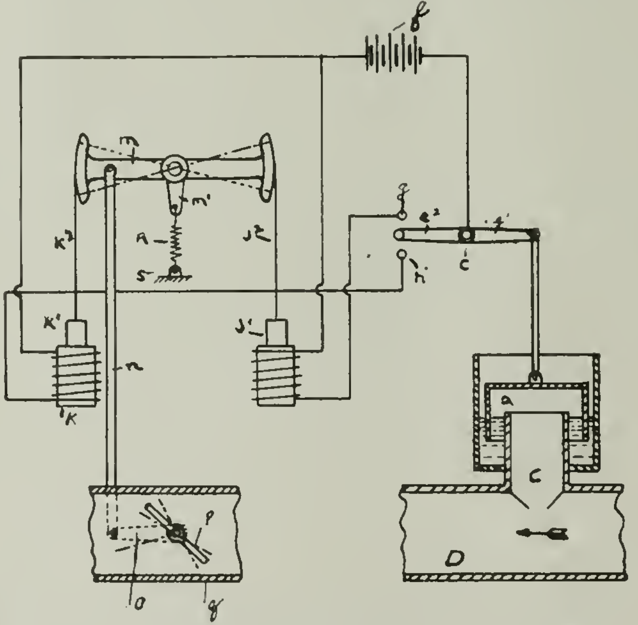

Fig. 7—Diagrammatical view of governor arrangement by Simon-Carves.

The valve is loaded by a weight, spring or other means so that when the circuits through both solenoids are broken, either on normal conditions again obtaining after the valve has been partially closed or further opened, or in case of failure, the valve assumes its normal partially open position. Generally the quadrant *m* is fixed like shown in Fig. 7, with a central arm *m*1, to which is connected one end of a spring *r*, which has its other end connected to a fixed point *s* and which brings the quadrant and at the same time the valve to normal position when the circuits through both solenoids are open.

Governor by Bamag, Berlin.

A comparatively simple device for adjusting the pressure of clean gas, particularly high pressure gas, at very distant points of delivery is shown in Figs. 8 and 9. The receiver connected to the gas main near the point of delivery is shown in Fig. 9 in section and consists of a cup-shaped receptacle flanged together in the middle and holding a metal disc diaphragm which by a vertical rod in center acts upon a balance lever carrying on one end a counterweight and playing with the other between two electric contacts. In the bottom of the receptacle is a gas inlet connected to the gas main so that the pressure of the gas acts upon the diaphragm and by its movements gives contact with the end of the balance lever. The contacts are connected to a few electric cells or a low tension battery and by wires to a contact arrangement of the governor, which is placed in the gas main near the works. The governor is shown in section in Fig. 9, being a direct acting device operated by the gas pressure, which influences a diaphragm. This arrangement offers the advantage that compared with the older types no attention is required to keep the water, in which a bell flows at a certain level and in addition renders the arrangement by the absence of water unaffected from frost. The center of the disc, serving as a diaphragm, is connected to a vertical rod holding on its lower end a valve, sliding in a seat placed into the main gas passage. The gas pressure underneath the diaphragm is adjusted by a special valve operated by two electromagnets which are influenced from the receiver shown in Fig. 8. Thus if the pressure on the point of delivery increases, the receiver makes contact and transmitting a corresponding contact to the governor causes by the action of the valve, operated by the electro magnets, the pressure under the diaphragm to be increased and the foot valve thereby to be raised proportionately. If the pressure drops at the point of delivery, the pressure under the diaphragm is also caused to drop by the same means and the foot valve is correspondingly opened. At the moment the electric circuit is broken, the valve spindle readjusts the steering lever automatically to its normal position, while in closing the circuit the contact is broken again in the one or the other direction by means of an electro magnet so that the lever can play freely.

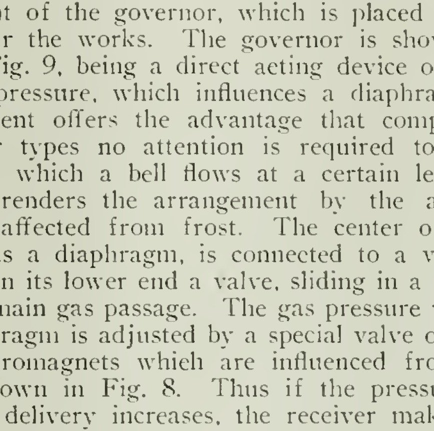

Fig. 8—Diaphragm receiver to governor by Bamag of Berlin.

The sensitive electric portion of the governor is protected by a casing with glass window and locked to prevent strangers from tampering with it. The effect of the foot valve can be altered within wide limits by turning the valve piston by means of the handle seen under the bottom of the governor in Fig. 9. For this purpose the valve piston is provided with two wings, and the valve seat with two corresponding port holes, the area of each representing the fourth part of a circle. By turning the valve piston with the handle, the port holes can be opened or closed altogether and the capacity of the governor varied within wide limits. This additional feature is of particular importance for those works on which the volumes sent through the mains vary at times considerably while the pressure conditions are to remain constant irrespective of the load. It also enables the same governor to be used on works which expect a considerable increase of gas deliveries gradually or in time to come. In both diaphragm casings, of the receiver as well as of the governor, the air escaped through a plug with a needle-fine opening. This slow escape and entrance of air serves at the same time as a buffer to the movements of the diaphragms and of the valve rod.

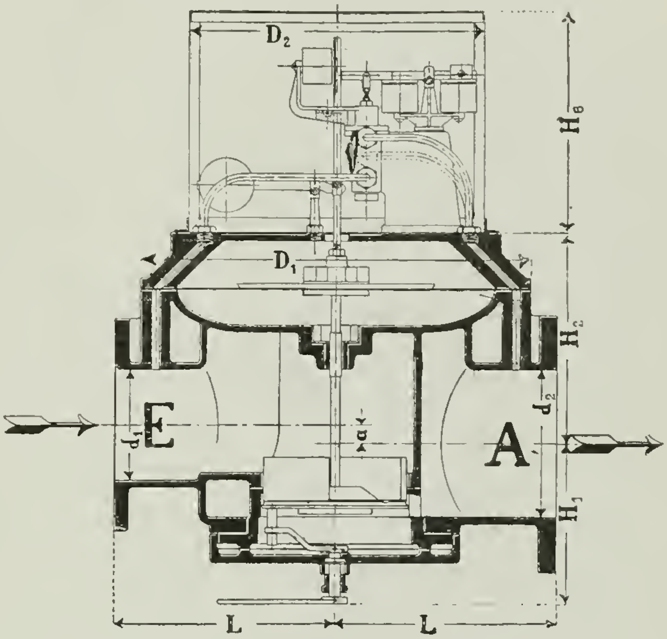

Fig. 9—Governor by Bamag of Berlin.

While the writer is particularly connected with by-product coke ovens, where electric governors have come to stay, they have in no small measure also helped to ease considerably the operations of blast furnace, producer and steel plants and have been largely introduced to all kinds of works handling large volumes of gas.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

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(My commission expires March 9, 1923.)

Selection and Heat Treatment of Tool Steel

In the Selection of the Proper Steel for a Tool There Are Various Intricate Factors to Be Considered.

By S. C. SPAULDING
Metallurgist, Halcomb Steel Co.

TOOL steel as its name implies is steel adapted for the making of tools. The determining points of its adaptability are capability of fabricating, machining, forging, pressing, etc., and possibility of safely hardening or suitably heat treating to put it in condition for use. Of the two points the latter is the most important as we can afford some extra trouble or expense in fabrication if greater safety in hardening or better production from the hardened tool is obtained.

In the early days the problem was simple. There was only one kind of steel, the straight carbon from which to make all tools. The hardener did not need to worry about whether it was a tungsten steel or a vanadium steel requiring special handling in heating and quenching. As long as the proper carbon content had been selected he merely need bring it to the proper temperature, quench in water or brine, draw back the temper for the service required and all was well. This simple carbon tool steel ranging from 0.60 to 1.25 carbon is still widely and rightly used today for many tools. It is only where special requirements of speed, service, or duty are needed that the special tool steels are economical. It is often said that this is an age of specialization for every need a definite prescription. In the last few years many special tool steels have been developed and in the near future there can be no doubt that many new and seemingly revolutionary steels will be in use.

In selection of the proper steel for a tool there are certain factors to be considered.

(1) The amount and intricateness of machining to be done on it. If much stock is to be removed and complicated shapes to be cut it must machine readily. If we merely need to drill a hole in it ease of machining is not so important.

(2) Can the tool be readily ground to size after hardening or must it come through the hardening with minimum change in shape?

(3) Is it going to be easy or difficult to harden without breakage.

(4) Will it have steady cutting, have light shock or will it be subjected to heavy blows? Is it to do heavy duty work, removing maximum metal in minimum time or is the amount of metal to be removed small but the finish obtained on the piece important?

(5) The kind of material to be cut, metal, wood, fiber, paper, felt, etc.

(6) Will it operate on cold or hot metal?

(7) Is it to make only one or two pieces or must it turn out great numbers of the same kind of parts?

In regards the first point, practically any of the ordinary carbon, alloy, or high speed steels can be annealed to machine readily and under proper handling easily and safely forged. For some special purposes however as in fine wire drawing dies where only a simple hole need be pierced in them ease of machining is of secondary important and special steels are used which even in the annealed state are hard and are not capable of ready machining.

Considering the second factor in selection. In hardening steel expands, becomes less dense or in other words the same piece of steel after hardening is larger, takes up more room than it did before. Now as this hardened piece is tempered or drawn it contracts and at some certain temperature it will come back to its original density or occupy the same space as it did before hardening. If however it is necessary to heat it or draw it to so high a temperature that it becomes soft before it returns to its original size, as a tool it has become useless. The carbon tool steels were all found to be subject to this disadvantage. Where the tool was a simple one it could easily be ground to the required shape after hardening and warpage was not harmful. Where however the shape was complicated grinding was not always possible and lapping very expensive. You can readily realize for instance that fine thread gages where accuracy is vital would be prohibitively expensive if made from a steel which expanded so much in hardening that much metal must be removed by lapping. Again many dies are so intricate that they must be built up in sections which fit accurately together. If after hardening these sections are all out of shape much expensive grinding and lapping must be done. In the early days of manufacturing things were on a small scale and intricate dies not so common. As modern American production methods came into vogue larger and more complicated tools were designed and to meet these requirements the steel men developed an oil hardening nonchangeable tool and die steel. This steel hardens very deeply and though it has a normal expansion on hardening when drawn at a low temperature before any softening occurs it returns to its original size and shape. Since its introduction it has had a wide and wonderful use saving annually thousands of hours of otherwise necessary grinding and lapping. I consider the development of this steel one of the great accomplishments of modern metallurgy.

The third factor that of probability of breakage in hardening would if carefully considered by the tool designer and metallurgist who selects the steel save large amounts of money by preventing unnecessary breakage. Of course it is necessary in many tools to have keyways, sharp angles, abrupt changes of section, but many times their effect could be ameliorated by the generous use of fillets. There has been an encouraging tendency of late to recognize the danger of sharp corners and in place of the old square keyway we find most of the large tool manufacturers using the half round keyway having no corners. This change came as an economic necessity. When the production of tools in large quantities was attempted tools had to be hardened by large scale production methods, a particularly delicate one could not be picked out and nursed by an expert man. They were all put through together on an accurately determined time temperature basis and with the old square keyway the losses from breakage became prohibitively large. The large manufacturer thus found that as a matter of self preservation he must give careful thought in designing a tool to the elimination of all possible causes of breakage. Another very frequent cause for breakage is abrupt change of section thin to thick or thick to thin. Often it is impossible to change the design to eliminate breakage risk and again it is necessary to go to the same oil hardening non-changeable steel, as tools would invariably crack if of water hardening tool steel.

The fourth consideration that of the duty required of the steel is of prime importance in its selection for the tool. Steels which are made for heavy roughing or hogging cuts are not suitable for light finishing cuts. In removing a heavy chip at high speed the metal is pushed and torn off. The extreme edge of the tool does not have or need a keen edge. The work of the tool falls on an area just back of the cutting edge where the pressure of the chip comes. The tool will keep on cutting until the heat generated by this chip friction becomes so great that the nose gives way and the tool ceases to cut. Hence for this work the problem is to select a steel having maximum heat resisting powers, that is one which has the maximum resistance to softening under the operating heat. The tool should then be designed so as to have maximum heat conduction as the faster the heat is conducted away from the cutting edge the more work it will stand before breaking down. For these fields two typical high speed steels have been developed. One all around type which stands much heavy work yet when properly shaped and with light cuts will produce good finish, and hold a fair edge. The other type has greater heat resisting powers, will stand up to heavier cuts and on harder material but will not hold as good a finishing edge. For the small shop doing miscellaneous work the first type will be the best. The other is a specialty steel to be adapted to particular jobs. There are other tools where ability to remove large amounts of metal is unimportant, the main consideration being the taking of a keen edge and producing a good finish on the work. For this purpose the straight carbon or semi-high speed finishing steels are adapted. The manner of using the tool should receive important consideration. If it is to have great shock like a hammer die it must have a tough cushion interior to keep it from flying to pieces. Tool designers thinking only of the hardness feature have put high speed steel into hammer dies only to see them fly to pieces on the first blow, it is well to remember that a tool to resist great and repeated shocks must have toughness. Where this shock factor is absent we can make our selection by its cutting or working powers but where repeated heavy shock is present that must be the governing factor as we might select a steel to give us the hardest and densest die in the world yet if it flew to pieces at the start it would never be of much use to us.

The kind of material to be cut is a vital factor. The steel which does good work cutting steel does not always do so well in cutting brass, wood, fiber, felt, etc. For cutting felt or paper a very keen edge is necessary and the high speed steel made for roughing work would not be in the running with a high carbon straight carbon tool steel. Wood working tools for machine use must stand heat as they run at very high speeds yet the regular high speed steel would not do as though it might stand the heating it would be too brittle and break under the shock of striking a knot or perhaps a nail or spike without breaking or dulling the cutting edge.

Considering the sixth point, I may say at the start by hot metal I mean metal at least a red heat. When a tool works on hot metal it naturally absorbs some of the heat and in order for it to stand up it must exhibit resistance to wear when hot. Plain carbon steels do not exhibit this property to any great extent and we must turn to a special type of steel. During the late war until a hot work steel suitable for piercing shells was developed the production of this type of shells suffered for lack of piercing tools. Other jobs where special hot work steels prove their worth are, hot bolt and nut machines, riveting, hot shears, etc.

The last factor is one of economy rather than suitability of the steel for the tool. For instance, suppose we are making a punch and die for blanking out parts of which we need hundreds of thousands or millions, numbers beyond the possible production of any one die. The cost of the material of which we make the die is negligible compared with the advantage of increased production. We will therefore use the steel best suited to give the greatest production regardless of its cost. On the other hand if we are to make only one or two pieces with a tool it will not pay to use an expensive steel which is capable of high production where a cheap grade will make as many as we need.

This covers the salient factors to be considered in the selection of a steel for a tool. Careful consideration of them by metallurgists and tool designers or others who are to specify what goes into a tool would prevent many costly tool failures. Make it a rule to consider these points as the first step in designing a tool and if an uncertainty comes up consult the steel man before it is too late so that he can help you to make a perfectly designed, easy hardening high production tool.

Turning now to the heat treatment of the tool. Very few tools are useful in the condition in which they leave the tool makers hands. They almost always require hardening or toughening to some degree. This is accomplished by heat treatment. The usual procedure may be outlined as follows. First, heat to some definite temperature. Second, remove from the heating medium and cool in some manner. Third, reheat to some definite temperature to remove brittleness and produce the required degree of hardness and toughness.

To accomplish the first step we must have a means for heating. There are many ways of applying heat, from an open gas burner, blow torch, coal forge, gas or oil fired furnace to the most refined accurately controlled electrically heated furnace. To select the proper medium let us first consider what goes on when a piece of steel is heated. As the steel absorbs heat it gradually expands that is becomes longer and wider and thicker. As the heat increases this expansion increases at a definite and uniform rate until a point called the decalesent or critical point will be reached. As heat continues to be applied beyond this point the rate of expansion suffers a very great and sudden change. In fact the steel begins to contract. Now as the heat is increased beyond this point the steel commences to expand once more but at a much more rapid rate as shown by the increased steepness of the portion of the curve beyond C. **The steel expands first slowly then contracts then expands rapidly.** Suppose it is heating at a very rapid rate, the corners and the small projections getting hot much sooner than the main body, they must have expanded then contracted then expanded very rapidly just at the time perhaps when the main body to which they are attached was starting to contract. We easily see then that very severe and unequal strains have been set up in our tool and after we quench and temper it we will doubtless find a corner or small projection missing, or the piece may hold together but be badly warped requiring excessive and unnecessary expense for grinding and straightening. Suppose we place the tool in a furnace which though it may not heat rapidly is not of a uniform temperature at all points, then one portion of our tool will always be at a different temperature than another and the same strains set up as in rapid heating. We will draw the conclusion then that the tool must be heated slowly and uniformly if we wish to minimize warpage and breakage.

Having considered the effect of heating a piece of steel and obtained some conception of the ideal heating cycle let us inquire into the means at hand for carrying this process out. Heating devices are wide in number and in variety of design but few are fit for the work. The oldest and one of the simplest methods is the charcoal fire or coal forge. Here rate of heating and uniformity of heating are all a matter of skill and judgment. There is no fixed point to go by, the man simply heaps up a fire and works it down to get the conditions as he wants them. It is impossible in the forge to exactly duplicate conditions and the smith will turn out some wonderfully good and some woefully bad tools. If the fire is made very large it is hard to keep all parts at the same heat. The best chances for good work are with a small fire and small tools, yet I have seen shops where large and complicated pieces were hardened in a forge fire usually to the detriment of the piece. Another more modern but more to be condemned method is the gas torch you will find in many tool rooms. While it has its place in straightening, melting lead, etc., it is not suitable for tool hardening. Yet you will see a tool maker attempt to heat a fairly good sized piece in it for hardening. The result is nearly always poor. One side is blistered and decarburized while the other side is cold and if he gets it through without cracking it will have soft spots.

To turn to heating devices in which we at least have a possibility of carrying out our process in the proper manner we find electric, gas, oil, and coal fired muffle and semi-muffle furnaces. Full muffle furnaces are seldom used. The usual medium is the semi-muffle where the hot gases of combustion come in contact with the work to be heated. Electric furnaces have not a wide use in tool hardening due to their greater cost although they make an ideal heating medium. Gas is most used in tool rooms and small shops due to its flexibility and simplicity of installation, ease of control and absence of dirt. Oil is used in large plants where the number of furnaces in operation justifies the expense of installing pumps and tanks to utilize its cheaper cost. Coal is not suitable for a small furnace but may be used to heat large heat treating furnaces. As we have said that semi-muffle furnaces in which the gases of combustion come in contact with the steel being heated are usually used, the effect these gases may have on our tool becomes important. Free oxygen or carbon dioxide in the gases will combine with the carbon in the steel removing it first from the surface then deeper and deeper until we get a decarburized layer of appreciable depth which will not harden and spoils the tool unless it can be removed by grinding. Oxygen also reacts with the iron in the steel to form an oxide scale while carbon dioxide reacts only with the carbon and leaves no scale. A small amount of oxygen in the furnace gases is preferable to carbon dioxide as its action on carbon and iron forms a scale over the surface which on quenching in water will fall off leaving a hard finish. Carbon dioxide in the gases is more to be feared as it does not show its presence by scale formation and though the tool comes out of the quench perfectly clean looking it will have a soft surface of decarburized iron. The safest way is to so control our furnace atmosphere that we have neither free oxygen nor carbon dioxide present but have our gases all carbon monoxide as this gas will not react with a clean piece of steel. If the piece be coated with scale however from a previous oxidizing atmosphere the carbon monoxide will reduce this scale to iron and again we will have a soft surface on our quenched tool. The customary way of obtaining a reducing or carbon monoxide atmosphere is to supply insufficient air for complete combustion of our fuel. This is sometimes known as running with a smoky flame. Excessive sulphur in the fuel will cause a soft surface on our hardened piece but this trouble is seldom met with. The above applies to heating in semi-muffle furnaces or so called open fire hardening. Another process finding extensive use for many purposes is bath heating. Here a pot is filled with lead or a salt and heated in a specially adapted furnace till it is molten and brought up to the required temperature. Lead is the most used medium. However special salts and cyanide find wide use. In the use of a bath we have to guard against too rapid heating. A piece immersed in a bath at the hardening temperature comes up to heat in a few minutes as the heating is by direct conduction. Such a quick application of heat is not the best thing for a tool steel and where hardening baths are used a preheating bath or furnace should be provided so that in the final heat we only have to raise the temperature a few hundred degrees, as a general rule we might say that bath heating is best applied only to small and simply shaped pieces or where only local hardening is desired.

Having briefly covered the methods of heating we will turn to the next operation, that of cooling the heated piece. There are as many cooling mediums as there are liquids but only four that have any wide use. These in order of their speed of cooling with the most rapid are, first, brine, water, oil, air. Brine is useful where extreme hardness is desired and particularly where we do not have a circulating system.

Where we have a copius supply of cool clear water under pressure piped to our quenching tank brine is not necessary. Where however we merely have a tank with no inlet or outlet brine is to be preferred as it will give a more drastic quench than still water and its quenching powers will not fall so rapidly with rise in temperature. Oil at the start of the quench cools the piece almost as rapidly as water. The cooling rate quickly falls off however and as we get down around 800 deg. F. and below the rate is very slow. A water hardening steel unless in very small section will soften under this slow cooling. It is only certain of the tool steels which have been especially designed for it that will harden when quenched in oil. In the tool steel line oil quenching finds its greatest use in the hardening of high speed steel. Air is the slowest of the quenches and is used only occasionally for high speed and air hardening steels. The air is usually supplied as a blast which is applied to the nose of the tool. An objection to air quenching is the heavy scale that is formed. Special quenching mediums which might be mentioned are molten lead and salts usually at a temperature of 1,000 deg. to 1,100 deg. F. for quenching high speed steel. There is less liability of cracking and warping when this quench is used and the steel gets just as hard as when quenched in oil. A quench in a hot bath at 1,100 is not equivalent to a quench in oil and draw to 1,100. After a quench in a hot bath the tool should be removed, let cool down to atmosphere and reheated to 1,100 for drawing. Before leaving the subject of quenching I must say that in quenching as in heating uniformity is the watchword. More pieces are cracked from the quench being as you might say not drastic enough than from having too great a flow and pressure of water. Where our circulation is feeble and uncertain we may get a flow of water against one part and still water at others. This condition is likely to result in warpage and breakage. Have a copius supply under good pressure and our inlets so arranged as to give a uniform flow all around the piece and best results will be obtained.

The final operation in hardening of a tool is drawing or tempering. This consists in reheating to some point below where appreciable softening results but high enough so that the strains from hardening will be relieved and consequent brittleness taken out. A tool which has not been drawn will fly to pieces under the least shock whereas the same piece after drawing to the proper heat will stand considerable shock and still be just as hard after drawing as before. There are various methods of accomplishing this reheating or drawing. It may be done by the use of baths as oil, in sand on a hot plate, in front of a furnace door, by a torch or flame, or by heat left in the piece itself. The last method might in some respects seem the best but in practice is good only for small and simply shaped pieces. Where the piece is large or of intricate shape it is impossible to get all parts drawn uniformly from heat left in it. I have seen many times cubical or rectangular hammer dies, the face of which have been chilled and enough heat left in the back to gradually bring the face up to a tempering heat drawn by this method. It is not to be recommended because if the piece is of any size uniform drawing is impossible. The center part of the face gets hot first and although the hardener puts wet swabs on it in an attempt to hold it back till the ends and corners catch up he is never entirely successful. The piece should be cooled down further in the quench so that there is only enough heat left in it to slowly dry itself off then reheated for the draw. This is many times done on a hot plate or in front of a furnace door. This method is applicable where we want a soft back and a hard face but will not work where we want uniformity of draw in all parts. A piece which has been drawn on a hot plate from the back up will show a steady gradation of hardness from the face down. If it is a die which is to be used many times over by grinding off the face we will get in trouble for as we grind off we get into softer and softer metal. For uniform drawing a bath in which the tool can be immersed or a low temperature oven is the only method. For a bath oil is used up to 550 deg. F. and molten lead and salt mixtures above this. Drawing ovens are usually heated by gas or electricity. The great majority of tools exclusive of high speed are drawn at 375 deg. F. and under, only when extreme hardness is not necessary do we go higher, where toughness and not great hardness is desired we go to 450 deg. F. and sometimes 500 deg. F. Drawing is a progressive phenomena and time at temperature is a vital consideration. In all the above I consider the piece to be held thirty minutes at heat. Thirty minutes has been found to be sufficient time so that a rather stable condition has been reached. This means that the same result will be reached in thirty as in forty, fifty or twenty-five minutes, whereas if we drew our piece for only five minutes increase or decrease of a few minutes would have a marked effect. If a piece be held several hours at heat more effect may be produced than in thirty minutes but for all practical purposes thirty minutes is ample time. Another great advantage of the bath or oven is that a thermometer or other temperature measuring device will give us an accurate indication of the temperature obtained. When drawing on a plate or other simple heat we have no indication of the temperature but the color it assumes at certain heats. This is an inaccurate indication as all steels do not take the same colors at the same temperatures and the condition of the surface and the kind of light effect the color. What will appear as a light straw color by artificial light will be no color at all by day light. A disadvantage of the oven heater as compared with the bath is the impossibility of telling just how long it takes different sized pieces to become heated through. At the low temperatures used for drawing it doubtless takes several hours to thoroughly heat a large piece in an oven whereas in a bath where the piece is totally immersed it becomes heated quickly and the size makes very little difference provided the bath is large enough to contain it. An advantage of the oven is cleainless. In either type care must be taken not to have the steel being drawn touch the bottom or sides of the container.

NEW HIGH RECORD

The blast furnace of Weirton Steel Co., Weirton, W. Va., on March 15, established a new high record for one day's production of pig iron from one furnace when it tapped 845.6 gross tons of pig iron. This is the second record made in a week by this furnace which on March 9, produced 826.1 gross tons, thus surpassing the former production mark previously held by No. 1 furnace, Pittsburgh Steel Co., Monessen, Pa. In the first 15 days of March the furnace of Weirton Steel Co. produced 11,105.3 gross tons, an average of 740.35 gross tons per day.

New Reversing Valves for Open Hearth Furnaces

A New Construction of a Bell Valve Is Described, Consisting of Two Parts Which Are Separated by Water Cooled Partition Wall—Many Disadvantages of Regular Type Valves Are Overcome.

By HUBERT HERMANNS

THE simplest and even today most commonly used valve construction for open hearth furnaces is the simple cylinder valve, a hollow, cylindrical and at the lower end open body with built-in partition, which keeps the gas current airtight against the outside by means of a water seal.

A disadvantage in this simple but efficient construction lies principally in the partition wall, which, under the influence of the hot gases, is destroyed in a comparatively short time, therefore necessitating the repair or complete change of the valve. The valve can only be inspected during shutdowns of the furnace and it happens therefore quite frequently that the valve is used in a defective condition. This results in heat losses, increase in working time and lower production. Another disadvantage of this bell valve of the usual design is the way in which the valve is made airtight. Under the constant influence of the hot gases, the water evaporates in large quantities and enters the furnace with the gases, resulting in larger quantities of slag and other drawbacks to operation.

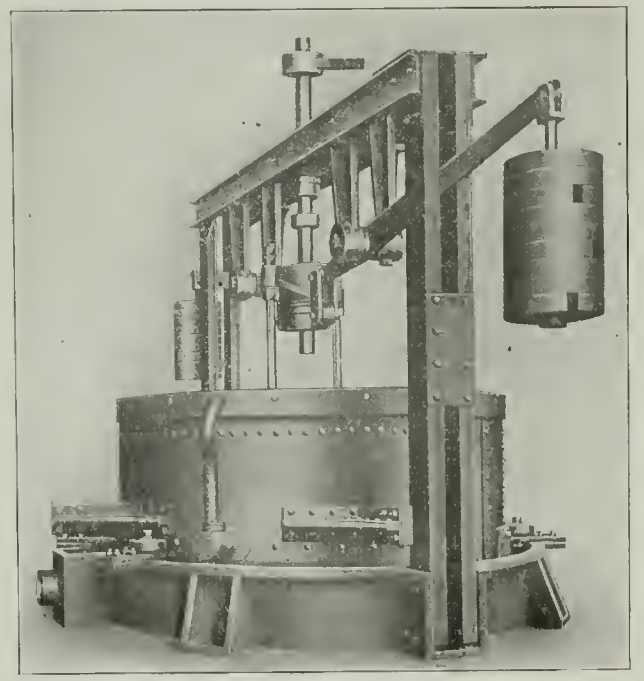

Fig. 1.

A new cylinder valve, in which the above mentioned disadvantages are eliminated, is made by the Mannstaedter-Works A. G. at Troisdorf near Cologne. In designing this valve, the main point was to protect the partition walls from the destroying influences of the hot gases and on the other hand to construct the valve in such a way that the partition walls can be inspected even during the time the furnace is in operation. The valve is made in two halves and connected in such a way that between the two inner walls serving as partition walls, an air space is kept, allowing observation and inspection of the partition walls even during the operation of the furnace. Through this space cooling water can be admitted, thus practically omitting the danger of demolishing the partition. To prevent the water vapors from entering the combustion chamber, an angular ring made of cast iron is inserted on the inside of the water seal, whereby the water surface is covered. The cooling water is admitted by means of two tubes. The water vapors coming from the water seal keep the water in constant circulation between the inside of the cylinder and the cylinder cover. Even the web of the cast iron ring is protected by the cooling water against the damaging influence of the hot gases.

Fig. 1 shows the outside view and Figs. 2 and 3 cross section and top view of one of the hand-operated valves, built according to the above specifications.

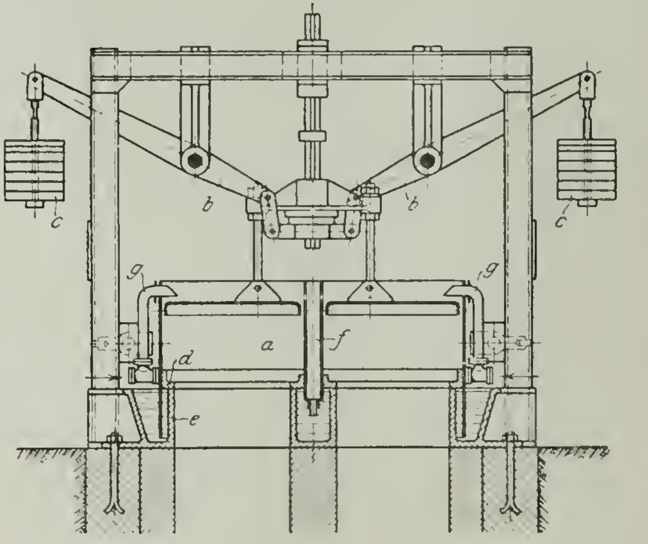

Fig. 2.

The cylinder *a* (Figs. 2 and 3) hangs on levers *b* with counterweights *c*. The cast iron ring *d* lies in position on the inside wall *e* of the water seal, thus separating the water seal from the gas chamber. The middle partition *f* consists of two parallel iron plates between which the cooling water flows through pipes *g* and then into the water seal. While turning, the cylinder is guided by guiding rolls *h*.

Another remarkable feature is the Mannstaedter gas reversing valve, operated automatically. The valve seat has an inside diameter of 26 inches. The cast iron valve plate is hanging on a rod, which is held by a cable of ½-in. diameter. The valve body, made of sheet steel, has a cast iron cover, through which the valve rod passes by means of a split stuffing box and a split gland. The explosion door, arranged on the side, is of the usual construction. To equalize the weight of the valve plate, a lever with counterweight is provided.

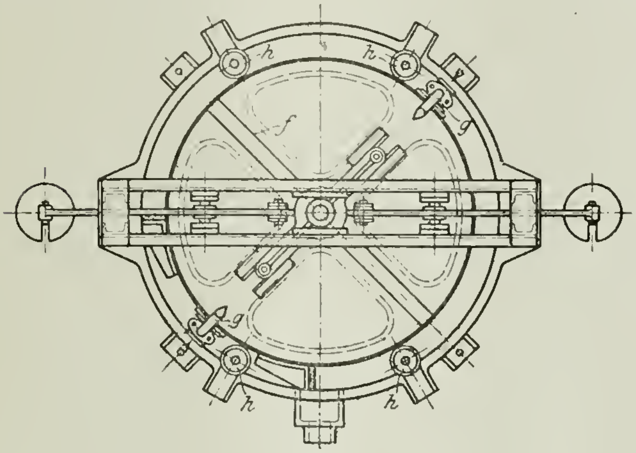

Fig. 3.

The connection with the valve described is effected in such a way that the cable, running over a roll, shuts down the gas valve automatically as soon as the bell is raised. While with the ordinary valve construction during reversal the gas flows without resistance to the chimney, in our valve, the loss of gas during reversal is eliminated, therefore resulting in the saving of a considerable amount of gas and coal. In spite of not having any dependable test data, it is safe to assume for a furnace with a capacity of 100 gross tons per 24 hours that during the whole melting time approximately 40 reversals are necessary and that each reversal requires about 10 seconds; we then have 400 seconds or nearly 7 minutes for every charge. Furthermore for each charge 4 minutes are needed for getting the furnace ready, since this is also done during the middle position of the valve. Thus the valve during each charge lets the gas escape to the chimney for 11 minutes, i. e., for the whole double shift 4 × 11 = 44 minutes. If the total coal consumption is taken as 24 gross tons in 14 hours and the price at $3.00 per ton, we have a saving of coal of $\frac{1440 \times 24}{44}$ = 785 or about 800 kg. or 1,765 lbs., which corresponds to a saving of about $2.36.

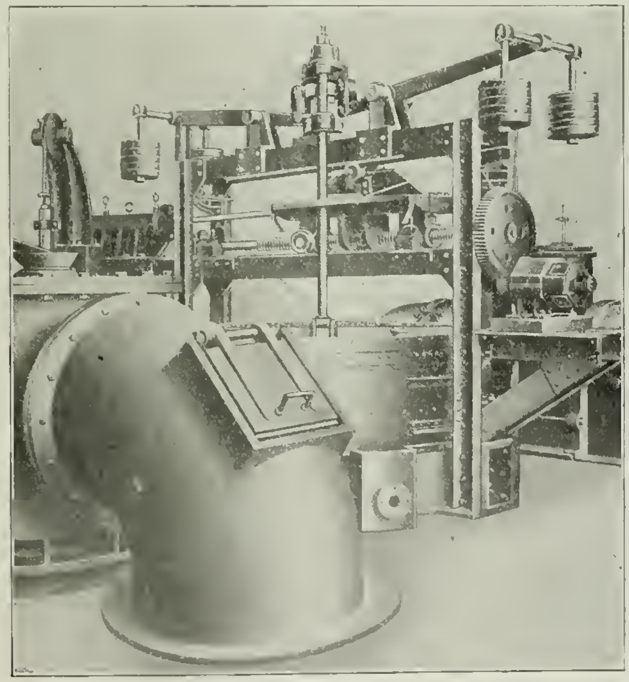

Fig. 4.

As a matter of fact, the escape of gas during reversing should be assumed to be much higher, since the gas flows in the direction of the chimney with almost twice the velocity, on account of not finding any resistance. For this reason it is a very conservative estimate to place the saving from a 25-ton furnace at $4.75 for double shift.

In general, the cylinder valve is operated by hand, but for larger valves, automatic operation is advisable, especially then when the bell valve is operated simultaneously with the gas valve and the air valve. For the automatic operation, electricity, compressed air or high pressure water are acceptable. In most cases, however, electricity will be preferred, since electric power is no doubt to be found in every steel plant and the operation of the electric motor is very simple.

In the design shown in Fig. 4 electric power is used together with compressed air in order to permit in case of necessity the use of one power for the other, thus preventing long shutdowns.

The operating motor is reversible and moves back and forth by means of gear strains and a screw shaft, a curved disc which is located in a horizontal receptacle.

SUCCESSFUL USE OF BLAST FURNACE GAS.

Extraordinary results have recently been achieved in the John Cockerill Works at Seraing, Belgium, by the utilization of blast-furnace gas as a source of power. For a period of seven months, the whole of the electrical power required, has been produced by gas engines driven by the gas supplied from a single blast-furnace. The results certainly tend to prove the reliability of the gas engine to be equal to that of the steam turbine; in fact, the power produced in this manner, is equal to more than twice that available from the steam turbine.

When it has been necessary to stop the furnace for a short while, the time chosen has generally been when the power station might conveniently be closed down, say, Sunday. To re-start, the furnace has been blown by a cupola fan, giving sufficient gas to purge the mains up to the gas-cleaning plant. This has then been started, and gas delivered at sufficient pressure to allow of the engine running.

Tests show that 35 per cent gas is absorbed by the hot-blast stoves, 10 per cent by the gas-blowing engines, 5 per cent lost, and 50 per cent available for the gas-driven central electrical power station. For a consumption of 200 tons coke per 24 hours, the load shown at the central station was 4,000 kw., equal to an average load on the gas-engines of 77 per cent of their fuel power.

Iron and Steel Classified for Designers

A Brief Survey of Wrought Iron, Malleable Iron, Cast Iron, and Semi-Steel with Special Reference to the Physical Properties, Characteristics, Common Uses and Heat Treatment of the Same.

By WM. J. MERTEN

Materials and Process Engineering Department, Westinghouse Electric & Manufacturing Company

ONE of the functions of engineering is the utilization of theoretical knowledge and available experimental data coupled with practical experience in the solution of similar problems. In the construction or design of a machine or structure, the analysis of such problems requires two distinct phases of engineering knowledge, one is purely designing, the other involves the selection of proper materials and their application. A systematic and intelligent survey of the known metals and materials and their characteristics is of primary importance in order to produce a safe and economic machine or apparatus.

The selection of the best suited materials requires:

1. A definite understanding of the specific physical properties which can best meet the particular requirements; that is, whether hardness, strength, toughness or some other property is most desirable to render the metal resistant to the stresses to which it is to be subjected. This is a very important point and only meager information and data are usually obtainable, being however, the determining factors in choosing from the ferrous or non-ferrous groups of alloys.

2. It is essential that the modifications of the physical properties and characteristics that may be brought about by thermal or mechanical treatment be known. By one or another of the usual methods of heat treating the same material may be made to answer the requirements of entirely different service stresses. For example, a low carbon steel in its annealed condition answers where malleability is wanted and moderate stresses are encountered. This same low carbon steel carburized and properly treated answers for heavy wear resisting service, such as journals for shafts, running at fairly high speed, camshafts, gears, piston pins, etc. A medium carbon heat treated steel gives strength, toughness and fatigue resistant properties wanted in axles, tires and rails, motor shafts, crankshafts, etc. A high carbon steel, treated, gives external hardness, high elastic limit and comparatively low ductility. Carbon spring steels are of this class and, when carefully manufactured, possess elastic properties highly desirable in this type of machine.

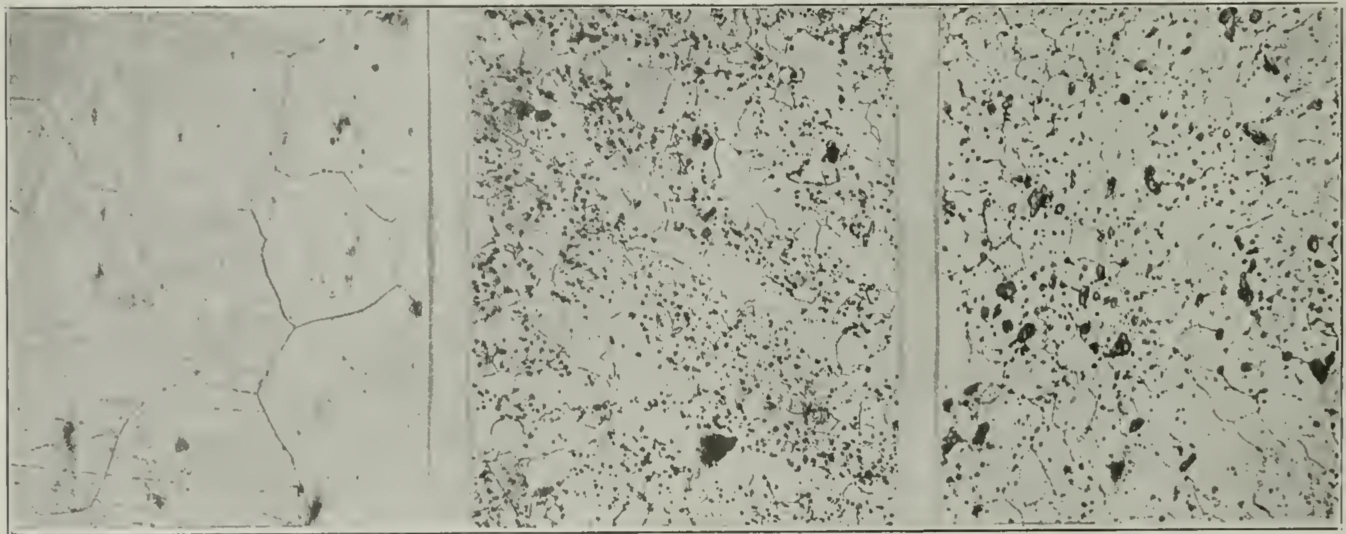

Fig. 1—Coarse grained wrought iron after forging and welding.

Fig. 2—Wrought iron annealed 825 deg. C. for 48 hours.

Fig. 3—Wrought iron refined by heating to 925 deg. C. and air cooled.

Magnification ×55 diameters in each case.

3. A fair understanding of proper methods and equipment for such treatment and processes is necessary in order to correctly prescribe them and predict with some degree of assurance the performance of the treated part.

4. The effect of mass and sections upon the rate of cooling, upon the resulting hardness and other physical properties of steel must be understood. Nonuniform sections contribute to warping and cracking of intricate dies, tools and machine parts. Surface imperfections influence the strength of the part being heat treated, drilling, punching, rough turning, polishing, saw cutting and shearing all have a positive or negative effect upon the strength of the material. Even

cooling of all parts is more essential than drastic cooling. Uneven cooling and the consequent distortion by enormously high internal strain is responsible for many failures which might be prevented by proper agitation of and continuous cooling, in an evenly tempered bath. Inactive layers of oil or water become heated forming non-heat conducting gas pockets which result in soft spots in the heat treated part. These soft spots are responsible for an early failure of the part because of the non-uniform structural condition. Obviously these are all factors of greatest importance.

5. The influence of alloying elements, differentiation between steel castings, drop forgings, press forgings, cold drawn parts and a knowledge of the advantages and short comings of forge welding, gas welding, electric welding (fusion, resistance and arc weld) is needed for the designing and production of a machine of merit.

Characteristics, Common Uses, and Heat Treatment of Wrought Iron.

Characteristics.—Wrought iron is made by the puddling process and is the purest variety of commercial iron, usually containing less than .08 carbon and approximately 1.00 per cent slag, the peculiar orientation of which is responsible for its remarkable resistance to corrosion and for its fibrous structure, allowing a large degree of plastic flow or movement within its crystal aggregate which makes it weak in compression. Wrought iron is very ductile and malleable, bending through an angle of 180 degrees or doubling flat on itself without breaking. It melts at a temperature of 1600 deg. C. and is still sluggish and viscous at temperatures so high that it is not practical to cast it into molds.

Uses—Wrought iron has high magnetic permeability, making it useful for lifting magnets. It is made into wire, sheets, rods, nails, spikes, bolts, chains, anchors, horse-shoes, tires, agricultural implements, boiler-plates, stays, grate-bars, etc.

Heat Treatment.—Wrought iron of fine grain structure is produced by forging or hot working. When reheated it undergoes a slow grain growth at a temperature of 500 deg. C.; this growth becomes more rapid between 700 deg. and 750 deg. C. and a prolonged heating at this temperature will produce an exceedingly weak and coarse grain, which is not altered or refined below or at 870 deg. C. Heating to about 900 deg. C. to 925 deg. C. will cause a breaking up of the coarse granules and results in a fine grain structure of good strength.

Wrought iron chain and crane equipment, when heated for welding of links and rings, has sections heated within this range of dangerous grain growth. To break up and reduce this coarse grained structure a heat treatment consisting of heating to 925 deg. C. followed by an air-cooling is given.

This difference in grain size of refined and coarse iron is shown in Figs. 1, 2 and 3, and the increase in values and magnitude of physical properties is given in Table I.

Ingot iron, a commercially pure iron made in the open hearth furnace, when worked at temperatures below 1000 deg. C. develops abnormally large crystals and will break and fail on forging, exhibiting the phenomenon called "Red shortness." Ingot iron is red-short between 800 deg. C. and 1000 deg. C. The rolling and hot working temperature is kept well above the upper limit to produce sound sheets and bars.

Malleable Iron, Its Characteristics, Uses and Heat Treatment.

Characteristics.—Malleable iron is cast iron of special chemical composition, melted in a reverberatory or air-furnace, and on rare occasions in a cupola, then cast into molds of its final form. The resulting casting is entirely white or all carbon is present in the combined form as iron carbide (Cementite Fe_3C).

Annealing in iron scale (Fe_3O_4) and sand packing at a temperature of from 760 to 925 deg. C. for a time period of 40 to 60 hours changes the carbide to the free amorphous carbon and ferrite, thereby rendering the casting malleable and very ductile at room temperatures.

Malleable iron is lower in carbon, silicon, sulphur, phosphorus and manganese than gray cast iron. It is, therefore, more viscous and must be cast from a higher temperature than the former; consequently it requires greater skill and care, on the part of the molder, to avoid misruns and excessive washing and scoring of the mold from the highly heated metal.

Malleable iron castings combine the advantages of ordinary gray iron castings with respect to the ease of production and cost, with a ductility and strength approaching that of steel.

A typical composition of malleable iron is as follows:

Graphitic Carbon	Combined Carbon	Silicon	Manganese	Phos.	Sulphur
2.50	.01	1.00	.20	.20	.06

The resistance of malleable iron to shock is great and this in conjunction with good ductility, causes it to flow under shock, and renders it highly resistant to fatigue stresses, crystallization, or low temperature effect. It resists corrosion well and its coefficient of friction is less than steel.

Uses:—Cylinder castings, bearings, shells, refrigerating cylinders and pipes, castings for air valves, ammonia castings and motor bearing housings and frames, sprocket chains, conveyor chains, parts of machinery where anti-friction and non-corrosive properties and strength is a desirable combination, auto-

TABLE I—PHYSICAL PROPERTIES OF WROUGHT IRON.

	Ultimate Tensile lb./sq. in.	Yield Point lb./sq. in.	Elongation in 8".	Reduction Area.	Brinell Hardness.	Specific Gravity.	Specific Heat.	Coefficient Expansion 100° F.
As rolled	48,000-50,000	32,000	30%	26%	90	7.78	.11	.00068
Normalized	50,000-52,000	40,000	28%	30%	120	7.78	.11	.00068

Melting Point.	Modulus of Elasticity.	Resistance per cm. ft.	Temperature Coefficient of Resistance per deg. F.
1600° C.	25,000,000	60	.0032

mobile accessories, such as clamps for wheel rims and buckles for tire straps and holders.

TABLE II—PHYSICAL PROPERTIES OF MALLEABLE IRON.

Specific Heat	.1298
Specific Gravity	7.21
Ultimate Tensile, lbs. per sq. in.	50,000
Yield Point, lbs. per sq. in.	20,000
Elongation in 2 in.	8%
Ult. Compression	50,000
Modulus of Elasticity	15,000,000
Brinell Hardness	80
Melting Point	2200° F.
Coefficient of Expansion	.00000617

Its application for material in draft gear cylinders is highly satisfactory. Its abrasive friction is very low on account of the carbon existing in the amorphous form, preventing the surfaces from becoming glazed under constant frictional wear.

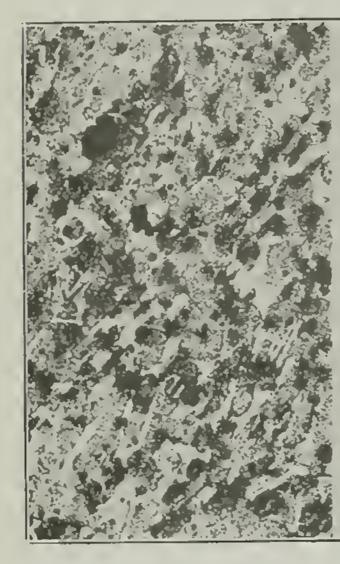

Fig. 4 (at the left)—White iron as cast showing cementite plus cementite eutectic.

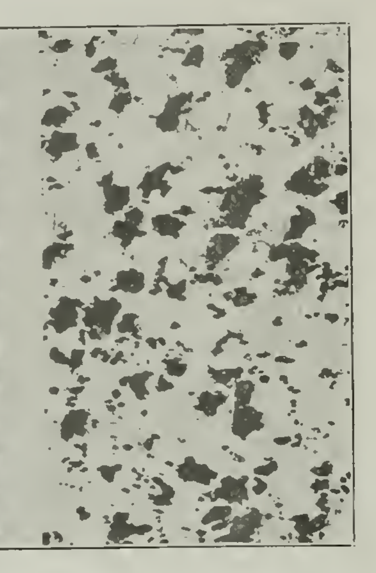

Fig. 5 (at the right)—Malleable iron structure in which the carbon is all separated out. The fracture is sooty and black.

Heat Treatment.—Heat treatment of malleable iron consists in heating for malleableizing by annealing the casting at the correct temperature and for a sufficient time period.

Annealing temperatures of malleable iron are materially influenced by its chemical composition, especially by the percentage composition of sulphur and phosphorus, the temperature being higher as the percentage of phosphorus and sulphur rises. However, no detrimental effect because of the increase in these ingredients is noticeable after proper annealing unless this increase is abnormally large.

Figs. 4 and 5 show the structure of malleable iron as cast and after being properly annealed.

The transverse strength of a 1-inch square bar on supports 12 inches apart is 4500—5000 pounds.

Deflection—¾-inch to 1¼-inch.

Modulus of rupture—55,000 lbs. to 90,000 lbs. per sq. in.

Gray Cast Iron—Its Characteristics, Uses and Heat Treatment.

Characteristics and Uses.—Cast iron differs markedly from wrought iron and steel, chemically as well as in physical characteristics. It has a coarse, crystalline grain structure, lacks toughness and is brittle at all temperatures below its melting point. The tensile strength is not affected at temperatures below 1000 deg F. but falls off quickly near the critical range and becomes very low at high temperatures.

It melts at a low temperature, 2200 deg. F., and passes suddenly into a very fluid state and fills the molds well when cast.

Cast iron is used for columns, posts, bases, bearing plates, machinery frames, motor bedplates and frames, and other structural parts where complex forms not subjected to severe service are needed and it is without a competitor in this line.

Gray cast iron contains a large amount of graphitic carbon, appearing in an irregular elongated aggregate of crystalline carbon resembling curved flakes or plates imbedded in a matrix of ferrite and cementite. The percentage of free graphite or graphitic carbon in gray cast iron depends upon the percentage composition of the other chemical constituents of the iron, such as silicon, manganese, sulphur, phosphorus. Silicon more especially influences the separation of graphite on cooling of the iron from the liquid to the solid. However, ordinary machinery iron contains approximately 3 per cent carbon and .50 per cent combined carbon. A typical composition of gray machinery iron castings is as follows:

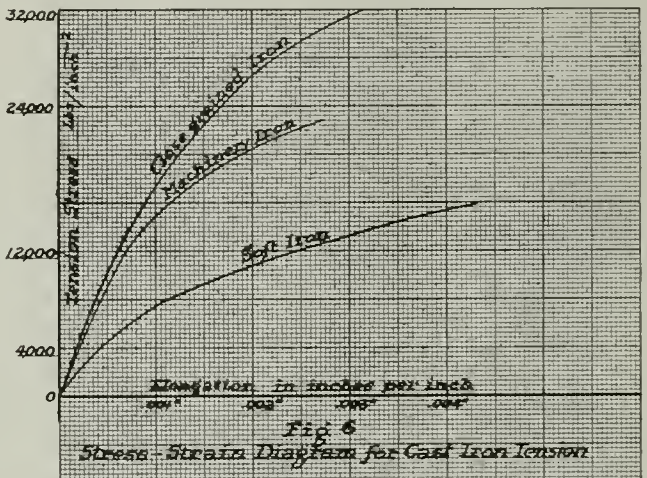

Fig. 6
Stress-Strain Diagram for Cast Iron Tension

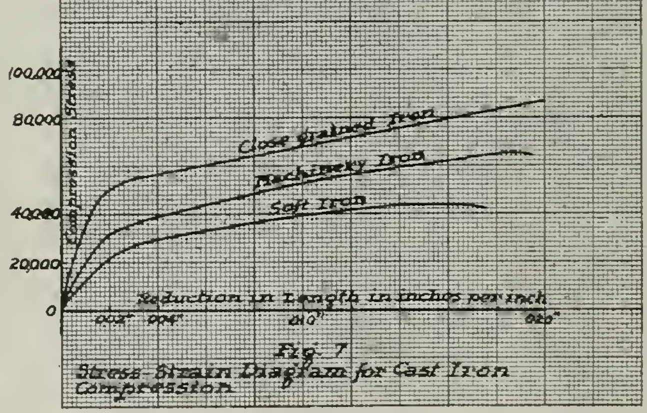

Fig. 7
Stress-Strain Diagram for Cast Iron Compression

Graphitic Carbon	3.1 %
Combined Carbon	.40%
Manganese	.45%
Sulphur	.09%
Phosphorus	.40%
Silicon	2.25%

The relative proportion of combined and graphitic carbon is of greatest importance and is the determining factor of the physical characteristics of the iron. The variation of the percentage of elements other than carbon is of importance only with respect to their influence on the proportion of combined and graphitic carbon. Silicon decreases the percentage of combined carbon, while manganese, sulphur and phosphorus increases it. Phosphorus, however, reacts in this manner only when present in fairly large quantities; its beneficial action in cast iron consists in reducing the melting point, making the iron very fluid. For perfect impressions of ornamental designs iron of high phosphorus content (about 1 per cent) is used.

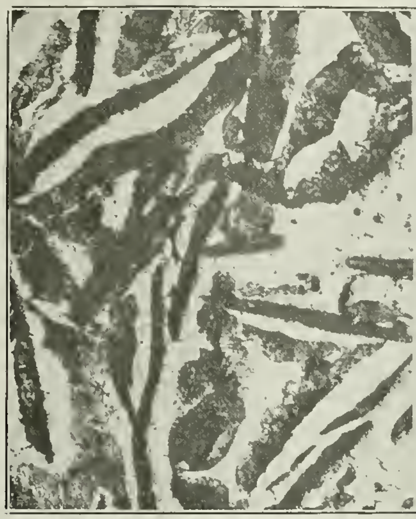

Fig. 8—Very soft and open gray cast iron showing large flakes of graphite. This is a very weak iron.

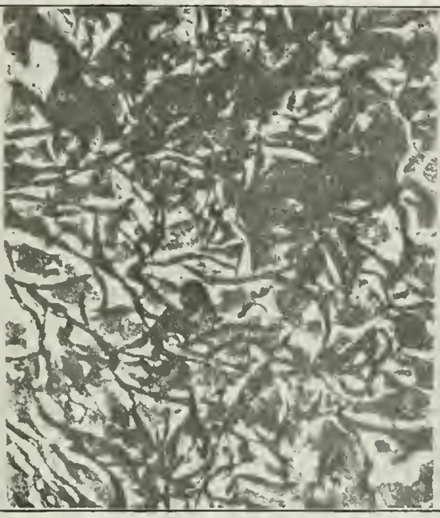

Fig. 9—Ordinary gray iron for machinery castings.

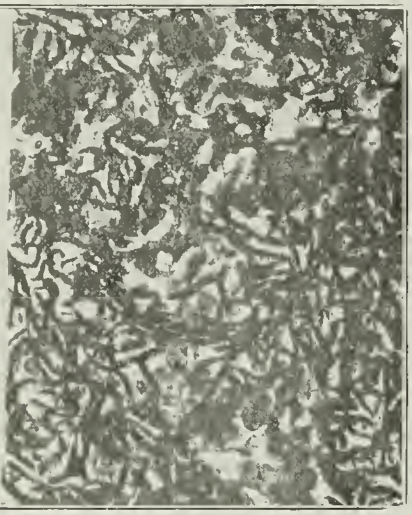

Fig. 10—Close grained iron of fairly high strength.

Magnification ×75 diameters in each case.

Other factors influencing the strength and physical properties of cast iron are:

1. Size of Casting.
2. Method of Molding or Founding.
3. Design.

It is obvious from the above that cast iron has no well defined elastic properties. The yield point varies from 5000 lbs. for soft iron to 22,000 lbs. for close grained iron and the ultimate tensile strength varies from 15,000 lbs. per square inch for soft iron to 35,000 lbs. for hard iron.

The modulus of elasticity also varies with the quality of the iron and changes with the intensity of the stress, or expressed in other words, (1) The slope of the gradient of the stress-strain curve is different for the different grades of iron. (2) The stress strain ratio is constant for very small loads or stresses only and changes or diminishes for larger loads or stresses, from 29,000,000 for close-grained iron at 3000 lbs. per square inch load to about 18,000,000 at 18,000 lbs. per square inch load.

For machinery iron the modulus of elasticity for small loads up to 3000 lbs. per square inch is about 24,000,000 lbs. per square inch and falls to 15,000,000 at 15,000 lbs. per square inch load. For soft iron the modulus of elasticity is about 14,000,000 at loads up to 3000 lbs. per square inch and 7,000,000 at 8000 lbs. per square inch load. This behavior of cast iron is illustrated in stress strain diagram, Fig. 6, and average working values of modulus of elasticity are given in Table III.

Cast iron shows enormously wide variations in compression strength values. Very large and long structural columns rarely have an ultimate crushing strength more than 30,000 lbs. per square inch. Short small sections, however, have a crushing strength of from 50,000 to 150,000 lbs. per square inch.

Moduli of elasticity in compression are very much better than in tension and are 30,000,000—20,000,000, and 12,000,000 for the three classes of iron at about 15,000 lb. per square inch stress, reducing to 24,000,000, 15,000,000 and 8,000,000 respectively at 24,000 lbs. per square inch stress.

Transverse strength, or cross breaking strength, of cast iron, is now universally accepted as the criterion of the quality of the iron—and the extreme fibre stress produced, causing rupture, is the modulus of rupture and is 52,000 pounds per square inch, 45,000 pounds per square inch, and 40,000 pounds per square inch, respectively, for close grained, machinery, and soft gray iron. The distance between supports is 12 inches. (See Fig. 1 and Table III.)

Figs. 8, 9 and 10 strikingly demonstrate the differences in micro-structure between the various grades of iron.

Heat Treatment.—Thermal or heat treatment of gray cast iron usually consists of chilling the metal in the mold during solidification from liquid. For example: Chilled cast iron rolls, car wheels and hammer blocks. Close grained internal combustion cylinder castings are frequently heated to around 480 deg. C. to 540 deg. C. to relieve casting strains.

Semi-Steel (High Test Gray Iron), Its Characteristics, Uses and Heat Treatment.

Characteristics.—Semi-steel is gray iron of such composition with regard to silicon and carbon as to give the highest possible strength in conjunction with other properties and characteristics inherent to gray cast iron. Properties such as high compressive strength, low coefficient of expansion, rust-resisting qualities, low melting point, high abrasive resistance, great hardness, wearing properties, and others are ob-

TABLE III—PHYSICAL PROPERTIES OF CAST IRON

	Ultimate Tensile Strength in Lbs. Per Sq. In.	Yield Point in Lbs. Per Sq. In.	Ultimate Compressive Strength in Lbs. Per Sq. In.	Modulus of Elasticity in Tension.	Modulus of Elasticity in Compression.	Modulus of Rupture in Lbs. Per Sq. In.	Melting Point in Degrees Fahr.	Coeff. of Expansion per ° F.	Spec. Heat.	Electrical Resistance per Circular Mill Foot.
Close Grained Cast Iron	35,000	20,000	120,000	30,000,000 at 3,000 lbs./in.^{2} Load to 15,000,000 at 10,000 lbs./in.^{2} Load	30,000,000 at 15,000 lbs./in.^{2} Load to 24,000,000 at 24,000 lbs./in.^{2} Load	52,000	2200	.0000068	.11	684
Machinery Iron	30,000	15,000	100,000	24,000,000 at 3,000 lbs./in.^{2} Load to 14,000,000 at 10,000 lbs./in.^{2} Load	20,000,000 at 15,000 lbs./in.^{2} Load to 15,000,000 at 24,000 lbs./in.^{2} Load	45,000	2200	.0000068	.11	684
Soft Iron	25,000	10,000	90,000	12,000,000 at 3,000 lbs./in.^{2} Load to 7,000,000 at 10,000 lbs./in.^{2} Load	12,000,000 at 15,000 lbs./in.^{2} Load to 8,000,000 at 24,000 lbs./in.^{2} Load	40,000	2200	.0000068	.11	684

tained by melting a mixture of foundry pig iron, gray iron scrap, and from 10 per cent to 40 per cent low carbon steel scrap in a cupola and casting the liquid iron into green sand molds.

Uses.—For castings requiring strength, wearing qualities, heat resisting properties, and close grain structures impervious to air, steam and water, semi-steel castings have no equal.

For hammer die blocks and die liners for piercing or extruding dies and tips for piercing arbors. Semi-steel made by melting with pig iron, and gray iron scrap a 40 per cent addition of steel scrap has given very much superior service at one-fourth the price per pound of high grade special steels.

An average chemical analysis of such die liners is as follows:

Graphitic Carbon	2.20
Combined Carbon	.80
Manganese	1.00
Silicon	1.30
Sulphur	.08
Phosphorus	.13

The physical properties of the semi-steel whose composition is given above would be:

Ultimate Tensile	49,000
Yield Point	40,000
Brinell	241
Transverse Test, 5,800 lb. load to rupture	
Modulus of Elasticity	8,000,000
Modulus of Rupture of	120,000
Melting Point in deg. F. or slightly higher than cast iron	2,300
Coef. of Expansion per deg. F.	.0000068

Heat Treatment.—The thermal or heat treatment of semi-steel consists in chilling of wearing surfaces in the mold when casting the metal. White castings so produced lend themselves to annealing and graphitizing of the combined carbon but this is not practiced commercially. Photo-micrograph 11 is a 10 per cent semi-steel casting structure from a fairly heavy section (3 in. diam).

Photo-micrograph, Fig. 12, illustrates a chilled section of a liner casting for an extruding die. This mottled hard and brittle jacket cushioned against a soft yielding gray iron section made an ideal die liner and increased production of extruding or piercing steel sleeves from 650 to 750 per steel liner to 4000 to 6000 per semi-steel liner, at a considerably reduced cost per liner.

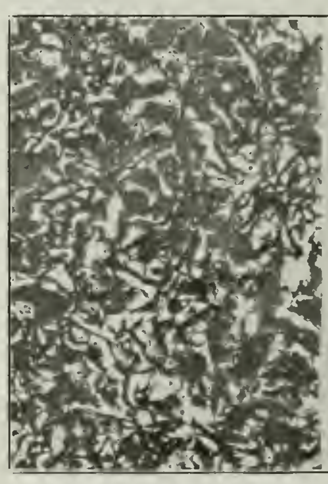

Fig. 11—Ten per cent semi-steel structure from a section 3 inches in diameter.

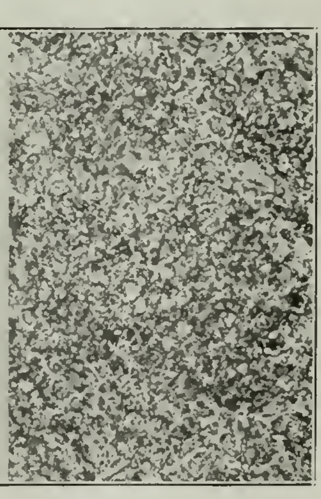

Fig. 12—Killed part of semi-steel casting. The white areas are cementite in a matrix of an aggregate of ferrite, pearlite and graphite.

A comparison with the structure of white iron made in the air furnace for malleableizing reveals a striking difference, the semi-steel chill being nearer comparable with a steel section at higher magnification. The writer has always attributed this similarity to the high percentage of manganese present in the semi-steel casting.

Acid Open Hearth Process for Manufacture of Gun Steel and Fine Steel

Detailed Description of This Manner of Work, Giving the Various Steps of Manufacture—Result of Investigations Made by Special Committee as to Difficulties Encountered.

By W. P. BARBA and HENRY M. HOWE

PART II

A GOOD deal of metal rich in inclusions is likely to accumulate on the very bottom of the ladle and particularly about the stopper, because the relatively cool ladle bottom cools the steel first tapped upon it, and thus thickens it, and impedes the rising of the inclusions which it contains. Therefore, the first 300 or 400 lb. of steel which run through on raising the stopper should be poured into an old mold set up beside the regular ones, and should be treated as scrap. The ladle should then be brought over the regular molds, but in doing this at so early a stage before the stopper and nozzle have become highly heated, care should be taken not to close the stopper tightly lest it should stick in the pasty metal when we try to reopen it.

37. **Temperature and Rate of Pouring.**—(a) These need to be governed accurately so as to steer between two grave dangers, that of causing external cracks in the ingot from too hot or too fast pouring; and that of causing external roughness and of increasing the quantity of inclusions by too cold pouring.

(b) As the first part of the liquid steel is poured into its mold, its outer layer which is in immediate contact with the cold iron walls of the mold cools down quickly through the transfer of its heat to those walls, with the consequence that a thin crust of solid steel soon forms on the outside of the mass, and thickens progressively. As it thickens the pouring of the steel continues, so that the top of the column of steel in the mold rises continuously. Thus as the crust of solid steel encasing the still liquid interior of the ingot progressively thickens, it is exposed to a continuously increasing hydrostatic, or ferrostatic, pressure.

This increase may be so rapid that the hydrostatic pressure outstrips the increasing strength of the solid crust of the ingot, and thus bursts it, forming one or more external cracks. These form all the more readily because at this stage the mold itself is rapidly growing hotter, and therefore expanding and drawing away from the ingot crust, the outer layers of which are cooling and hence contracting.

Both hot pouring and fast pouring increase the tendency of the hydrostatic pressure to outstrip the strength of the crust, and thus to crack it—hot pouring because it retards the thickening of the crust, and fast pouring because it accelerates the increase of the hydrostatic pressure. This is one of the most important reasons for the American practice of cold pouring, the other reason being that it gives quick solidification and shortens the pipe.

Here cool pouring is the equivalent of slow pouring. Each favors the thickening of the solid crust relatively to the lengthening of the column of molten steel, and each thus guards against external cracking. This leads to the simple rule that the steel should be poured at so low a temperature and so slowly that the solid walls at the lower part of the ingot will thicken fast enough to resist the progressively increasing hydrostatic pressure caused by the gradual rise of the upper surface of the metal.

An additional and closely related effect of the slow pouring is to shorten the pipe. This is because the steel cools more slowly in the ladle than in the molds, so that slow pouring prolongs the period during which we add fresh hot steel to the ingot top, while the lower part of the ingot is cooling by transferring heat into the mold walls. In general, slow pouring makes for keeping the ingot top hot.

(c) A further objection to hot pouring is that to raise the temperature of the molten steel is to raise the temperature to which it heats the mold walls at any given instant, hence to retard the cooling of the steel, and in particular to retard its passage through the solidification range. In this way hot pouring leads to a greater degree of differentiation in solidifying, to the formation of larger dendrites, and to a higher degree of enrichment by segregation in the interdendritic spaces and probably in the axial region. The crucible steel maker long ago noticed the marked columnar structure of ingots poured too hot, and called those with this structure "scorched."

38. **Cool Pouring.**—(a) If, on the other hand, the steel is too cold when it is poured, or is poured so slowly that it becomes too cold before the whole of it has entered the mold, two serious troubles arise. First, the extremely slow rising of the upper surface of the molten metal in contact with the cold mold easily causes the surface to crust over momentarily for a short distance. These slight crustings may not be entirely effaced by the metal poured in later if the steel is extremely cold.

(b) Another and still more serious damage by too cold pouring is the retention of inclusions. Steel poured so cool that the thickness of the solid walls of steel gradually forming in the mold increases fast enough to resist the progressively increasing hydrostatic pressure, must evidently be very near its solidus as it enters the mold. At any rate, it must be well below its liquidus, and therefore it must be an emulsion of particles of solid steel supported in molten steel. This point must be grasped clearly. The lower the temperature is the greater will be the proportion of solid particles to molten steel; and the more viscous therefore will be the emulsion of which the steel itself consists. Evidently this viscosity impedes the attempt of the particles of slag to rise to the surface.

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*Abstract of paper presented at the New York Meeting, February, 1922, of the American Institute of Mining and Metallurgical Engineers.

(c) Another danger in the top pouring of ingots at too low a temperature is that, should the nozzle leak, so that its spittings form a thin sheet which solidifies on the side of the mold above the level of the steel, the metal poured later may not be hot enough to remelt this sheet, which thus remains to form a discontinuity. As it melts at its bottom, it may fall down into the molten metal below, or tilt over and catch on the opposite side of the mold. Evidences of this have frequently been observed and thoroughly traced to this cause.

39. **Summary.**—To sum up the three advantages of cool pouring which we have now seen, that it restrains segregation probably both axial and interdendritic, the size of the dendrites, and the tendency to external cracking, outweigh its disadvantage of favoring the retention of inclusions in the opinion of American open-hearth experts, but not in that of Continental European ones and at least some of the British, who purposely pour their gun steel extremely hot. Indeed, even their workmen regard the external cracking to which hot pouring leads as a favorable symptom, for the cracks can be chipped out while the greater freedom from inclusions persists. In our opinion the question is an open one, to be decided by careful observation. Yet because our paper is to describe American practice, we shall continue to speak of cool pouring as among the aims of the process.

Cool pouring is considered further in Section 47.

40. **Notes on Pouring.**—(a) The interval between tapping and teeming and the rapidity of teeming are governed by the melter's judgment as to the temperature at which the steel left in the furnace, and by the size and number of ingots into which the charge in the ladle is to be poured. The length of time occupied in teeming each ingot should be recorded carefully for the melter's guidance in future cases., If the ingots show external cracks, referable to too hot pouring, he would infer that he had poured too fast for the actual temperature of the steel. If, on the other hand, the ingots show the characteristics which we associate with too cool and hence too slow pouring, such as an excessive quantity of inclusions, he infers that for the existing conditions he has teemed too slowly. Laps and cold shuts on the corners of the ingot are clear evidence of too slow pouring.

(b) Each heat of steel, and each ingot of each heat, forms in itself a problem for the melter, whose judgment and experience are now called into operation, since it is well nigh impossible fully to lay down rules governing the pouring. In all cases the melter, who should be the most experienced man available in the establishment, should himself watch the steel in each ingot as it is rising in the mold, and judge the temperature of the metal and the speed of pouring required for each, carefully recording the actual time and the conditions of the resultant ingot. The proper rate of pouring cannot be predetermined; rather it is estimated by the melter, with his experience in mind, from the observed temperature of the steel as it rises in the mold.

(c) It is obvious that top-poured ingots are difficult to watch in the way just mentioned. This matter will be discussed more fully when top and bottom pouring are considered (Section 55).

(d) The temperature of the steel in the ladle falls continuously from the beginning to the end of teeming, with the effect that though the metal was slightly above its liquidus on entering the ladle, it falls to materially below it before the teeming is completed, so that some skull often remains. This skull represents metal too pasty, and hence too near the solidus, to flow over the bottom of the ladle. Its presence is a sign that the temperature and rate of teeming have been correct.

41. **Breaking Cream.**—It is a common saying that the appearance of bottom-poured steel as it rises in the mold should be that of "breaking cream." This is readily understood when we remember that the metal poured at the proper temperature is an emulsion much like that of the suspended butter fat of thick cream. Both are subject to crusting over with a very thin crust. In the case of steel, this crust caused by the cooling effect of the air in the neighborhood of the mold is quickly remelted by the hot steel rising from below, if the pouring temperature is proper.

42. **Stop-pours.**—(a) We should pour the steel into each mold without the slightest interruption, lest we form a "stop-pour," a slight freezing of the upper surface of the metal where it touches the mold, and fail to remelt it completely when we resume the pouring. This is especially important in the cool pouring recommended in this paper.

(b) Stop-pours may be made both in bottom-pouring and in top-pouring practice, and sometimes are difficult to detect, especially if the stoppage is very short. In any event, when a stoppage has occurred and the resultant stop-pour has escaped detection, it is likely to be discovered if the ingot is forged, but if the ingot is rolled discovery is much more difficult. Always after a stoppage there is certain to be a defect in the surface, extending to unknown depths into the section. For gun purposes, and others in which the ends only can be inspected and tested, a stop-poured ingot never should be considered for use. There are, of course, occasions when for bar steel or billet production, a stop-poured ingot can be carried forward and the stop-poured part cut out and discarded.

43. **Piping.**—(a) The reasons for the existence of the pipe is already familiar, namely, that at an early stage in the solidification the crust of the ingot has done a greater proportion of its total cooling, and hence of its total contraction, than has occurred in the deeper seated layers, and thus has been stretched by their resistance. Because these deeper seated layers therefore have from this time on a greater range of temperature to cool through than the crust has, they will undergo more contraction than it. This excess of contraction of the interior plus the stretching of the crust are represented by the presence of an axial cavity, or pipe, unless indeed it is compensated for by the formation of blow-holes or gas cavities.

(b) One of us * has already shown that the pipe forms in the last solidifying part of the ingot, whether that is at the top or bottom or at the side. Clearly it is well to have the pipe occur at one end of the ingot so as to affect only a short part of its length, and that end is preferably the top for obvious reasons.

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*H. M. Howe and Bradley Stoughton: Trans. (1907) 38, 117.

Hence the various devices for concentrating the heat at the ingot top, or otherwise causing the solidifying of the top to lag behind that of the parts below, so that, as fast as the pipe tends to form, it may be filled by still molten metal from above. Among these devices, are "hot-tops" to the molds, sink heads, having the large end of the ingots uppermost, pouring slowly, at a low temperature, and at the top of the ingot especially at the last, and of making the mold walls thicker below than above, so that they may cool the bottom of the ingot faster than the top. This will be considered further in Section 55, on top and bottom pouring.

44. **Top lag**, or the lagging of the upper part of the ingot in the process of cooling, may here be studied a little more closely because it helps explain why small ingots are nearly always top poured throughout, though larger ones are not (Section 55).

In any given transverse slice EE′ of a solidifying ingot, the temperature rises continuously as we pass from the outside toward the axis, while it simultaneously rises continuously as we pass from this slice upwards. The tendency to form an axial cavity or pipe proves that, while this tendency exists, the slice EE′ as a whole is contracting faster than the crust of the ingot. The parts E and E′ are held apart by the rigidity of the crust, and the excess of contraction of the crust gives the different parts of the slice a tendency to draw apart.

Lest it be thought that this tendency to crack open at the axis is confined to the temperature range between the liquidus and the solidus, a range indeed of great weakness, let us remember that pure substances, pure metals, pure eutectic liquids, etc., in which the solidus and the liquidus coincide and there is no freezing range but only a true freezing point, also pipe. Indeed this case is not needed to convince us that the slice EE′ may crack at its axis and may thus tend to start a pipe at any temperature at which the stretch AB caused by the resistance of the rigid ingot crust to the contraction of the slice because of its faster cooling, exceeds the stretching power of the metal; or in other words, when the stress so induced exceeds the existing strength of the metal. This range of temperature may extend far below the solidus.

45. **Pipe-closing Period.**—Imagine that the slice EE′ is completely isolated from the mass of metal above and below by the planes which form its top and bottom. In this case the pipe D, representing the excess of induced stretch over capacity for stretch, persists. But if, having thus imagined the creation of D, we next consider the actual conditions in which no such planes exist, we see that all of the metal above this plane which is still hot enough to have any appreciable capacity for flow, begins sagging down to close D, as suggested by arrows C and C′, quite as the faces of a prism of soft jelly sag when the mold in which it has set is withdrawn. The curved lines of flow of such concrete masses are not to be confused with the angle of repose of discrete ones like sand. Note that the sides of the funnel-shaped part of any pipe are curved and not straight.

Thus in every imaginary horizontal layer there is the pipe-forming tendency, representing the excess of induced stretch over capacity for stretch, and the pipe-closing tendency, representing the sagging of the overlying mass, and chiefly of its axial and periaxial parts, which are the hottest and hence the most mobile.

The pipe will stretch down to the layer in which the sagging of the overlying mass just fails to compensate fully for the pipe-forming tendency. Clearly the quantity of sagging down into any given layer must increase with the volume of mobile metal above the layer, and with its mobility, and this latter in turn increases with the steepness of the vertical thermal gradient from this layer up. In other words, in any given horizontal layer, the pipe-closing tendency increases with the mobility and hence with the temperature of the metal above, and these increase with the rapidity of rise of temperature from this layer up. Hence the importance of concentrating the heat at the top of the ingot, thus increasing the volume and mobility of the metal available for sagging down into any given layer, thus raising the position of the layer the sagging into which barely equals in volume the volume which the pipe-forming tendency represents, and thus in fine shortening the pipe.

Because the tendency to pipe is inversely as the steepness of the vertical thermal gradient in the upper part of the ingot, and because this steepness is inversely as the size of the ingot, other things being equal, the tendency to pipe and the depth of the pipe are greater in small than in large ingots. This result represents also the longer time available in large ingots for the sluggish process of sagging.

46. **Stub Ingot Pouring.**—In making "stub"* tire ingots, that is those the length of which is only 60 to 100 per cent. of their diameter, each making a single tire, the Standard Steel Works Co. combines various steps for causing the cooling of the ingot top to lag and thereby shortening and raising the pipe, and raising and concentrating the segregate so effectively that a discard of only 3 per cent. suffices to remove all unsound, piped, and harmfully segregated metal. This discard is the small disk punched out of the axis of the bloom into which the ingot is forged in working it into the shape of a tire.

Here the cooling of the bottom is hastened by the broad thin cheese shape of the ingot which exposes entended bottom surface to the cold thick bottom of the mold; and the cooling of the top is retarded by a layer of carbonaceous matter, which in burning yields much heat yet without causing material carburization.

47. **Cool Pouring Raises the Pipe.** — Section 37 shows that in top pouring we may raise the pipe by pouring slowly. Cool pouring has a like effect, as we will now explain. First, let us recognize that the molten steel cools down much more slowly in the ladle than in the molds. With this in mind the effect of cool pouring in raising or even eliminating the pipe can be made clear by considering two imaginary extreme cases.

First let us suppose that the steel when top poured into the mold is so extremely cool that it solidifies very rapidly, indeed almost immediately. In this case, the early poured steel solidifies very early in the pouring, and is thus anchored in place at the bottom of the mold. Each subsequent addition in like manner becomes anchored approximately at the height in the mold which it occupied when poured. These successive lots thus cool down by the transfer of their heat into and through the mold walls. Because the first poured lot starts this cooling earlier than the later ones, it will at any given instant be the coolest, and each of the successive lots, from the bottom upwards, will be hotter at any given instant than the one next below it. Thus solidification and the formation of the pipe proceed from below upwards, so that each layer, as it enters the mold, finds the pipe already formed or forming in that beneath it, and thus has the best possible opportunity to fill it. Indeed this, like any other means of causing the solidification of the top to lag behind that of the lower parts, clearly tends to raise the pipe.

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*Lawford H. Fry: Year Book Amer. Iron and Steel Inst. (1919) 435.

In bottom pouring the same is true, save that here we must conceive that the steel is at all times hot enough to keep a channel open through the earliest poured and earliest frozen layers at the bottom.

Turning now to the opposite extreme, let us suppose that the steel is so hot that none of it freezes before the whole ingot is poured. In this case the falling or rising stream keeps the whole mass in motion, so that the parts poured first become mixed with the rest, and that the progressive rise of temperature from the bottom upwards, so favorable to the raising and shortening of the pipe, is reduced to a minimum.

The principle which governs these two extreme cases applies to any intermediate one. The cooler the steel the more of the early poured parts will solidify and become anchored in the lower part of the mold, and the more rapid will be the rise of temperature at any given instant from the bottom toward the top, and hence the shorter and higher up will be the pipe.

48. **Shape of Molds.**—In designing the molds there are four important ends to be sought:

(a) That they shall have enough taper to prevent the ingots from sticking to them, but no more.

(b) That the crust of the ingot shall not be cracked transversely by its inevitably cooling and contracting faster than the deeper seated layers.

(c) That it shall not be cracked longitudinally by the same cause.

(d) That the pipe shall be shortened and raised as far as possible, or better still eliminated.

Let us consider the means to certain of these ends.

49. **Taper.**—(a) The taper is almost the same in ingots of five sizes, taken from current good practice, varying from 0.40 to 0.43 in. in diameter to the running foot.

(b) On pouring the ingot into its mold, its skin solidifies when its temperature is much above that of the mold so that the ingot in cooling has a greater range of temperature through which to cool than the mold, and hence contracts more. This excess of contraction of the ingot would naturally cause a gap between them, so that it might be expected that, were both perfectly smooth, no taper would be needed. In fact, neither is quite smooth. The ingot especially is likely to have roughness which may cause it to stick in the mold. Moreover, part at least of the gap to be expected between ingot and mold is effaced by the stretching of the ingot's crust caused by the resistance to its contraction by the slower cooling and contracting deeper seated layers, as well as by the stretching due to ferrostatic pressure.

(c) It is to afford the clearance needed for easy stripping that the taper is given.

(d) The amount of taper should be the minimum which experience shows is needed to enable carefully poured ingots to be removed from carefully prepared molds, because any great excess of taper makes the work of forging more difficult, and also leads to the faster heating of the smaller than of the larger end of the ingot.

(e) Further to prevent this sticking, the inner surface of the mold should be examined carefully to detect any roughness, and it should be coated, for instance with a wash of bone graphite and water, and polished to a "kitchen range" surface.

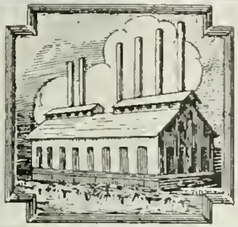
(f) It might at first be thought that more taper would be needed in small than in large ingots, because the average temperature of a large ingot at the time when its crust is solidified by being cooled by the mold and its external dimensions are thus determined, is higher than that of a small ingot. This suggests that the average contraction of a large ingot is greater than that of a smaller one. Because this excess of contraction helps to free the ingot from the mold, less taper would naturally be needed to give enough free space to enable the ingot to slip past the mold.

(g) But this advantage of the larger ingot is counteracted by its disadvantage as regards the stretching of its crust by the resistance of the slower cooling deeper seated layers. Both large and small ingots are stripped as soon as they have cooled far enough to be handled without danger of breaking, when the faces of the octagon or square are at about 850 deg. C. (1562 deg. F.), and the edges or corners are black, and these temperatures are about the same for large as for small ingots. But the average temperature of the large ingot at this time is much higher than that of the small one. Hence, the resistance of the slower cooling interior of the large ingot stretches its crust by an amount greater than the corresponding stretching of the crust of the small ingot. This greater stretching of the crust of the larger ingot lessens the clearance between ingot and mold, and this offsets to a certain degree, and perhaps completely, the excess of contraction of the large ingot to be expected from the considerations set forth in the preceding paragraph.

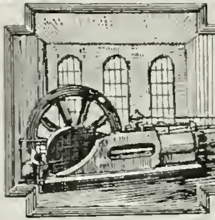
50. **Prevention of Longitudinal Cracks by Giving the Crust of the Ingot an Accommodating Shape.**—(a) A circular gutter pipe filled with water bursts on freezing, because the circular form of the metal has too little power of elongation to accommodate itself to the expansion of the freezing water. But a corrugated gutter pipe does not burst, because while its metal has no more capacity for elongation than that of the circular one, it has an accommodating shape.

(b) Following this line of reasoning, the crust of the ingot is given a similar accommodating shape, often that of a fluted octagon, in order that it may not be torn apart by longitudinal cracks in the early stage of solidification, when it is thin and tender, by the resistance to its contraction offered by the slower cooling of the deeper seated layers; but that instead it may bend and thus accommodate itself to the resistance.

(To be continued)



STEAM POWER DEPARTMENT



Improved Method of Burning Coal

Methods and Results Obtained from Wetting Coal with Exhaust Steam for Chain Grate Stokers—Ash Is Generally Much Better When Wet Coal Is Used.

By C. E. HAYES

IT has long been an established fact that certain kinds of coal burn better on chain grate stokers when properly wet than when burned dry. This fact is particularly true of the coals of Western Pennsylvania, Ohio and West Virginia.

In order to determine if a certain coal will give more efficient results when burned wet than dry, it is necessary to test it. This is very easy to do.

First, enough coal is placed in a pile on the floor to run the stoker for about an hour or two. This coal is dampened thoroughly with a hose and turned over several times with a shovel until it is uniformly wet through.

It is of great importance to have the coal uniformly wet and to see that there is just the right amount of moisture in it. Every one knows that the water in the coal has to be boiled and superheated to the temperature of the flue gases. This, of course, is a loss, and the more water in the coal, the greater the loss. While this loss —caused by wetting the coal—is more than made up by the added efficiency obtained, it is well to bear in mind that the coal should not be wet more than will produce the best results.

After a good deal of experimenting, it was found that the most practical method of telling when the coal has enough moisture in it, and still not too much, is to take a handful and press it tightly together. If it has sufficient moisture to mould and is not so wet that the water will run out of it, the best results will be obtained.

After the pile of coal to be tested has been dampened, level off the coal in the stoker hopper and put the wet coal in. Careful observations of the fire and ash should be made after the wet coal is put in the hopper. A decided improvement will be noticeable with most coals, as soon as the wet portion works back. The writer has observed that in most plants where this was tried, a stright line could be seen coming back across the boiler, separating the good fire obtained by burning wet coal from the poor fire of the dry coal. The ash is generally much better when burning wet coal.

In one installation, where force draft chain grate stokers are used, it was almost impossible to burn the coal dry, but after it was dampened much better results were obtained.

After it is established that a certain coal will burn better when wet, the question arises as to how to wet it successfully in actual practice.

The most general, but not the best, method is to install water pipes above the stoker hoppers and spray water on top of the coal. This method will work fairly well, but has decided disadvantages. In the first place, it does not wet the coal uniformly without putting a large excess of water on the coal. This excess of water not only means loss of efficiency, but it runs through the coal onto the stoker. Very often this water, after passing through the coal, is very corrosive and will damage the stoker. This is particularly true of force draft chain grate stokers.

If only a small amount of water is sprayed over the coal, it will make paths through the coal for itself and only wets a very small portion of the coal. This uneven wetting is worse than no wetting at all, because it makes the fire burn uneven.

To overcome this disadvantage of using water, the following method was installed and proved not only entirely satisfactory, but an improvement over the old method of using water.

There is generally an excess of exhaust steam around the boiler room of a steel mill. This exhaust steam was used to wet the coal. A two-inch pipe was placed in the stoker hopper 12 inches above the grate, and as near the front as possible. Into this pipe were set a row of brass plugs one inch apart, each with a 3/16-in. hole in the center. These brass plugs can be eliminated and the 3/16-in. holes placed in the pipe itself. If this is done, however, trouble may develop due to the holes stopping up with corrosion caused by the action of water on certain kinds of coal.

The 2-inch pipe with the holes in it was placed so that the holes faced in towards the boilers and down 15 deg. below the horizontal. This 2-inch pipe was connected to the exhaust steam header with a valve near the stoker so the amount of steam can be regulated, or shut off if the stoker is not in use.

The above arrangement has been given a thorough trial and found to be far superior to any method of using water. It wets the coal much more thoroughly and more uniformly without any excess of water. The coal will be wet enough to give the best results and still no water will run through the grates.

No trouble was experienced with escaping steam above the hopper as long as it was kept reasonably full of coal.

Economizers and Economizer Operation

Theoretical Need of Economizers—Progress Made in Steel Tube Economizers—General Review of the Advantages and Disadvantages of Economizers.

By FRANK H. PROUTY

Asst. Steam Engineer, Cambria Steel Co., Johnstown, Pa.

THE first economizer installation dates back more than 100 years; every year has seen an increase in the number of installations, yet it may be said that the economizer is still in a period of trial and transition and has never been fully accepted by the American engineering profession.

Old Installations Often Inefficient.

Certainly there are a number of economizers throughout the country which positively detract from the overall efficiency and which it would be cheaper to remove or permanently by-pass than maintain in operation. Such results may come from insufficient stack draft, improper proportioning of economizer heating surface to boiler heating surface, feed water temperature under 100 deg. F. causing extreme external corrosion and excessive soot caking, feed water temperature over 200 deg. F. which may be too close to the breeching temperature for sufficient heat transfer or the not uncommon failure due to neglect in operation. On the other hand there are economizer installations which will meet the manufacturers' entire claims and which are indispensible to high efficiency. Such results are obtained when there is 350 deg. F. to 450 deg. F. difference between entering feed water temperature and breeching temperature, an induced draft fan to provide ample draft, a proper relation between boiler heating surface and economizer heating surface, a counter flow relation between water and gases and a clean economizer.

Theoretical Need of Economizers.

The theoretical need of economizers becomes apparent for if heat is to be imparted to the boiler throughout the travel of gases over the tubes, the gases must manifestly leave the tubes at an appreciably higher temperature than the steam and water within. If the steam temperature is 375 deg. F. and the gases have an excess temperature of 125 deg., then the resulting stack temperature of 500 deg. may represent a loss of 15 per cent of the total heat available. A counter flow type of economizer placed between the feed pump and the boiler and in this flow of gases will most effectively reduce the gas temperature, the water having a high boiling point due to its pressure and high heat absorption because by flowing in a direction opposite to the flow of gases, there is always a maximum temperature difference between the two. The counter flow principal also minimizes temperature strains and with cast iron tubes and headers, this item rises to prominence.

The lower the temperature of the feed water entering the economizer, the lower will be the final gas temperature, yet the former should never be below 100 deg. F. and preferably well above this figure because low feed water temperatures cause moisture in the flue gases to condense on the tubes and headers and this moisture combining with the sulphur usually present in the gases, forms sulphuric acid and rapid corrosion invariably results.

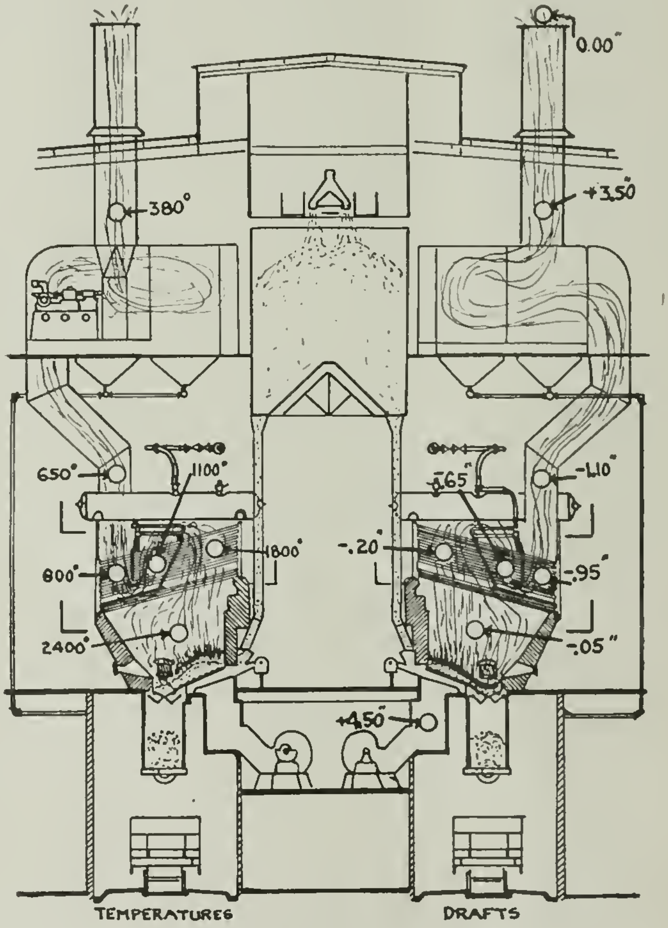


Fig. 1—Typical temperatures and drafts with Green economizers in a modern boiler house.

Economizers as Purifiers.

Economizers in a limited manner act as purifiers, causing the deposit of part of the solid matter held in suspension and precipitating out a large portion of the carbonates held in solution. Most scale is formed by the carbonates and sulphates of magnesium and calcium, the carbonates resulting in temporary hardness and the sulphates in permanent hardness. As only the carbonates are precipitated out in an economizer, it may be said that its purifying action deserves small consideration, it doing little more than relieving the boiler blow-off of carrying away a portion of sludge.

Progress Made in Steel Tube Economizers.

Economizers in this country have generally been made of cast iron and because of the tensile weakness of cast iron for high feed water pressures, numerous attempts have been and are still being made to perfect a steel tube economizer. Steel tube economizers have proven unsuccessful in the past because of excessive internal corrosion due to air held in solution with the feed water. Attempts to galvanize and otherwise coat the inside of steel tubes failed to prevent corrosion. However, recent experiments have shown that the air in feed water may be greatly reduced by maintaining a heater temperature near the boiling point, by filtering, or by forcing preliminary oxidation by passing the feed water over iron filings placed in the heater outlet. An improved method now being commercialized is to boil the water under a partial vacuum. This method not only gives an increased extraction of air, but has the additional advantage of treating water with a temperature well under the atmospheric boiling point. This latter point particularly benefits where the temperature of gases flowing through the economizer require that for maximum heat extraction the feed water temperature be down around 150 deg. F. A number of steel tube economizers are now under trial and with the present development of deaeration, some installations will undoubtedly prove successful. Cast iron economizers are also subject to internal corrosion, but so moderately that in very few cases has internal corrosion caused failure.

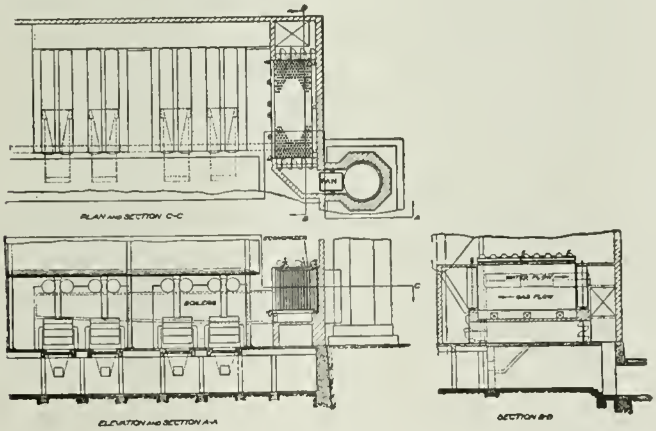


Fig. 2—Showing one Sturtevant economizer serving more than one boiler. The tendency is toward individual economizers for each boiler.

Replacing Mechanical Scrapers by Soot Blowers.

Economizer tubes collect an external deposit which requires constant removal and some economizers are equipped with mechanical scrapers for removing this deposit. There is a considerable amount of mechanism to these scrapers and, in recent years, a strong movement has been made to replace them by soot blowers. Soot blowers require less exposure of the attendant to the excessive radiant heat of the economizer, they can keep the economizer tubes cleaner, have a lower initial cost and can be operated and maintained at a considerably less cost than can mechanical scrapers. However, mechanical scrapers will successfully do their work and they have advantages in that they deposit the scrapings into the hopper underneath the economizer while the soot blower blows most of the cleanings out of the stack and the scrapers operate dry while the soot blowers deposit a certain amount of moisture on the tubes. The latter advantage is of small importance where the water entering the economizer is close to 200 deg. F. and where superheated steam is used to blow, the use of soot blowers may cause rapid and disastrous corrosion of the economizer. Some manufacturers factory equip their economizers with soot blowers, while in other instances scrapers have been replaced by soot blowers after the original installation.

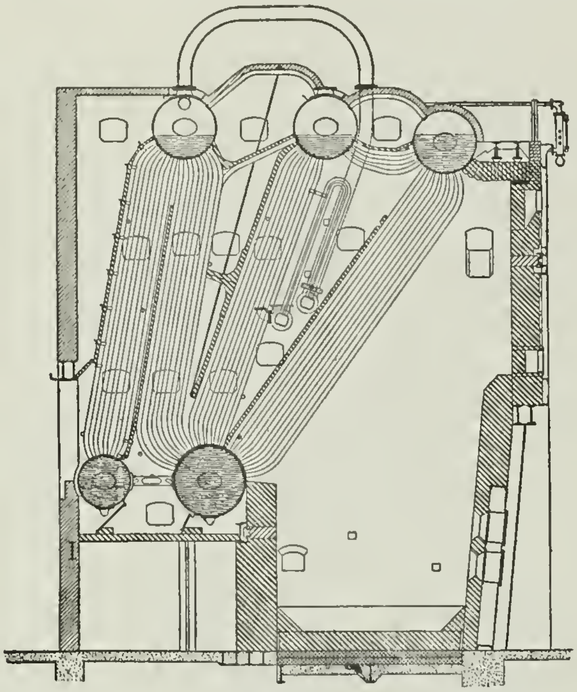


Fig. 3—Babcock and Wilcox Integral Stirling Type Economizer.

Induced Draft Fan Necessary.

It may be said almost without exception that good results will not be obtained from an economizer unless it is used in conjunction with an induced draft fan. The loss of draft gas due to gases cooled to around 350 deg. F., together with the additional resistance necessary to pull the gases through the economizer would require a stack prohibitive in size to carry peak loads or run high ratings.

The commonly used induced draft fan and short stack result in the emission of large quantities of dust, the controlling of which gives rise to a problem of considerable magnitude. This dust has been successfully controlled by an induced draft fan which also embodies a centrifugal dust catcher, the dust being driven by centrifugal force to the outside periphery of the fan where it is deposited and collected. This method removes but a portion of the total dust and the upkeep cost is large due to the abrasive action of the particles. Another method is to wash the dust out of the gases by passing them through washers. This method is expensive to install and a loss occurs in stack draft due to a cooling of the gases. The cheapest and simplest remedy seems to be that of attaching a collecting hopper to the boiler breeching and baffling the gases down against a series of louvre blades placed in the top of the hopper. These blades snub the dust particles and cause them to drop into the hopper below. As this dust often contains from 60 to 65 per cent fixed carbon, it is possible to burn it on a Coxe stoker.

Economizer Operation.

Cast iron economizer tubes are usually cleaned with water driven turbines, the water acting as a cushion and preventing the turbine from smashing the tubes. However, an air driven turbine can be used with equal success if equipped with a limit ring. After cleaning economizers several times it is often difficult to prevent the caps from leaking. In such cases hot joint paste is superior to pastes of lead or shellac.

When economizers are newly installed it is not unusual to experience a considerable breakage of headers. The cause may be initial strains in sections set up when section is assembled at factory, pressure shock in feed water lines, temperature shock due to cold air coming up through openings in hopper under economizer or by expansion strains due to local conditions. When a factory assembled header breaks and is replaced by a hand assembled header, the latter seldom breaks. In order to avoid pressure shocks, every economizer installation should have an air chamber in the feed line. This chamber may consist simply of a dead end pipe connected to the feed line and carried well up above the economizer.

Manufacturers of economizers once advised by-pass flues for by-passing the gases around the economizer when repairs are being made. It has been found that generally there is not enough use for a by-pass to warrant its existence and, when once installed, a by-pass is a constant annoyance due to leaks and damper disarrangements. If the induced draft fans are to be worked by automatic control, it is advisable to place a damper in the economizer breeching. This damper, if properly tied in with the fan, will assist the fan in finding its proper draft balance.

Economizers Not Always Installed in Modern Plants.

As previously stated, economizers have never been fully accepted by the American engineering profession and many modern plants are being built with economizers permanently omitted. However, most of these plants, instead of truly eliminating the economizer, have really made it an integral part of the boiler itself. The most common method employed when economizers are omitted on horizontal tube boilers is to build the boiler several rows of tubes higher than standard and this additional heating surface really amounts to an integral steel tube economizer. With vertical tube boilers, the additional tubes are added to the rear tubes of the boiler. One advantage of this method is that the increased resistance to gas flow is so small that an induced draft fan is not required and by insulating the breeching and lining the stack, it is possible to run high ratings on stack draft without induced draft fans. Of course, it is always possible to get lower final stack temperatures by using an economizer and hence higher overall efficiency, but it is a much mooted question whether the net financial gain will aways favor the installation of economizers. If it is decided to install economizers in a modern boiler house, a heat balance should be worked up very carefully to determine whether auxiliaries shall be steam or motor driven. It is usually necessary to motor drive some of the auxiliaries in order to avoid an excess of exhaust steam in the heater such as would raise the feed water temperature above the most economical temperature for economizer operation.

CLASSIFIED LISTS OF U. S. PATENTS IN THE CARNEGIE LIBRARY OF PITTSBURGH.

The Technology Department of the Library is now able to offer an extremely valuable service to those interested in patents pertaining to the chemical and metallurgical industries. The Department has secured lists of the actual numbers of patents in forty-eight complete classes of the United States Patent Office classification. These classes comprise approximately two hundred thousand patents, covering, in general, the entire field of chemistry and metallurgy. Within these limits the list should enable anyone to make a completepatent search. This is a form of service not available elsewhere outside the Patent Office, since the indexes printed and distributed by the Patent Office are of little value in making a thorough patent search by subjects.

The lists are arranged by classes and sub-classes. The following will probably be of interest to readers of The Blast Furnace and Steel Plant:

Class 22, Metal Founding. (Includes 219 sub-classes and contains approximately 5,867 patents.)

Class 29, Metal Working. (Includes 189 sub-classes and contains approximately 6,572 patents.)

Class 75, Metallurgy. (Includes about 16 sub-classes, containing approximately 1,350 patents on ferrous metallurgy.)

Class 78, Metal Forging and Welding. (Includes about 103 sub-classes containing approximately 3,286 patents.)

Class 80, Metal-Rolling. (Includes about 66 sub-classes, containing approximately 2,892 patents.)

Class 148, Metal Treatment. (Includes 32 sub-classes, containing approximately 3,222 patents.)

Class 158, Liquid and Gaseous Fuel Burners. (Includes about 121 sub-classes, containing approximately 8,444 patents.)

Class 183, Gas Separation. (Includes 122 sub-classes, containing approximately 2,880 patents.)

Class 184, Lubrication. (Includes 106 sub-classes, containing approximately 4,324 patents.)

Class 202, Charcoal and Coke. (Includes about 10 sub-classes containing approximately 688 patents.)

Class 204, Electrochemistry. (Includes sub-classes on electric furnaces and electrodes, containing approximately 1,224 patents.)

Class 205, Metal-Drawing. (Includes 29 sub-classes, containing approximately 610 patents.)

Class 207, Plastic Metal Working. (Includes 19 sub-classes containing approximately 379 patents.)

Class 266, Metallurgical Apparatus. (Includes 42 sub-classes, containing approximately 2,000 patents.)

Saving Steam With Soot Blowers

Saving in Steam Effected by Valve-in-Head Soot Blowers—Charts Showing the Steam Consumption of the Soot Blowers When Operated for Varying Lengths of Time.

By ROBT. JUNE

ONE of the outstanding features of the new Valv-in-Head Soot Blower (Fig. 1) is the steam saving effected by the unit valve being open just long enough to have the jets pass over the part of the tubes to be cleaned. With the cam adjusted to hold the valve open for 300 degrees the head uses steam from five to seven seconds per revolution. As the gear reduction assures turning of the element slowly and steadily, it is rarely necessary to revolve the blower more than two or three times. This means that steam is being used from 15 to 21 seconds per unit per blowing.

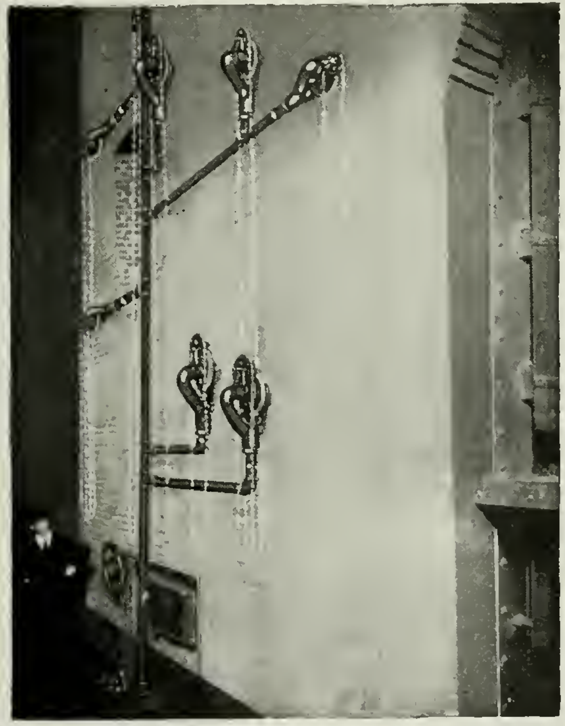


Fig. 1—Diamond Valve-in-Head Soot Blower.

In contrast the valve of the plain revolving soot blower is necessarily open from 45 to 75 seconds, 60 seconds being the average time required for close attentive operation.

At this point it is well to observe that very few men operating soot blowers realize the importance of giving proper attention to the steam loss due to unit valves being kept open longer than necessary to clean the boiler properly. We have timed a large number of soot blower operations, many of them without the knowledge of the operator, and it has been surprising to note the frequency with which the unit valves are kept open two and three minutes and even longer, while keeping the valves open from a minute and a half to two minutes is common practice. Fig. 2 is a chart from which the steam loss from excessive blowing can readily be computed. The vertical column of figures at the left is the steam pressure in the header when blowing, while the figures at the bottom show the amount of steam that will pass through a standard 5/16-in. soot blower nozzle at the various pressures in a given time.

The point at which the slanting lines intersect vertical lines for a given pressure indicates the steam flow through the nozzle for the time marked on each slanting line. By this method we find that with 100 pounds header pressure, 2.4 pounds of steam will flow through a nozzle if the valve is open 30 seconds, while 9.6 pounds will be used if the valve is left open 120 seconds.

Taking a standard 21 wide B. & W. boiler, we find we have five units of 20 jets each, or 100 jets. To blow this boiler by the Valv-in-Head system with the valves open 30 seconds each will require 240 pounds of steam, while with the independent valve soot blower if the valves are open 120 seconds each, 960 pounds of steam will pass through. If the boiler can be properly cleaned with the valves open 30 seconds, the loss would be 720 pounds per blowing, or 2,160 pounds in 24 hours, if the blowers were used three times a day. With the boiler in service 300 days a year, the steam loss would be 648,000 pounds. To reduce this loss to dollars and cents it is only necessary to multiply the cost of the steam from 20 to 70 cents per thousand pounds, by 648. If the steam costs 50 cents per thousand pounds, the loss for the boiler described above would be $324 per year.

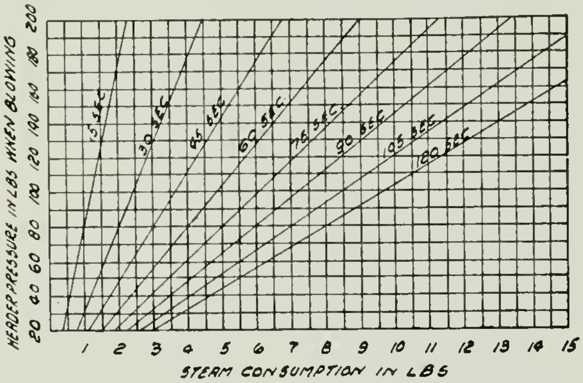


Fig. 2—Steam consumption for single 5/16 in. jet. Header pressure 40 to 120 lbs. when blowing. Valve open 15 to 120 seconds.

The chart, Fig. 3, shows the total steam consumption for a five unit 21 wide installation, on which the header pressure is 100 pounds with the unit valves open from 10 to 130 seconds. Fig. 4 shows the total steam consumption of installations on a 21 wide boiler with

100 pounds header pressure, having from one to fifteen units and blowing from 15 to 120 seconds each. From this it will be seen that a boiler with 14 units, having 20 jets each, and with 100 pounds header pressure, will require 690 pounds of steam per blowing, if the valves are open 30 seconds each, while 1,725 pounds will be required if the valves are left open 75 seconds each.

It should be noted that the pressures given are for the header while blowing. With one unit valve open the header pressure will be from 50 to 80 per cent of the boiler pressure, depending on the size of the piping, the bends and valves in the line, the number of jets on the unit and other conditions. The header pressure will always be somewhat higher than the pressure in the blower element, due to friction between the header and the element and in the element. This will also account for the discrepancies between these charts and the results obtained by the use of Napier's Formula.

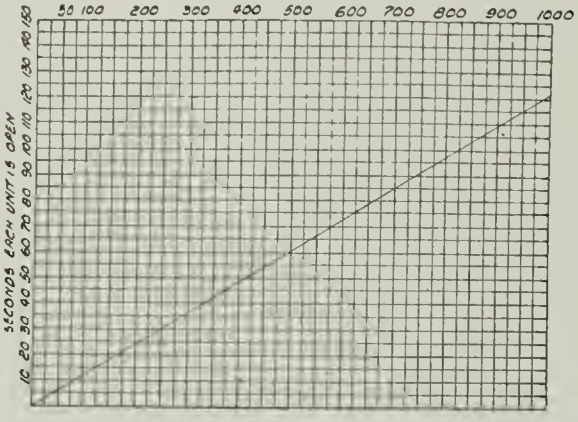


Fig. 3—Steam consumption in lbs. per 5 units on boiler 21 tubes wide. 100 lb. pressure when blowing.

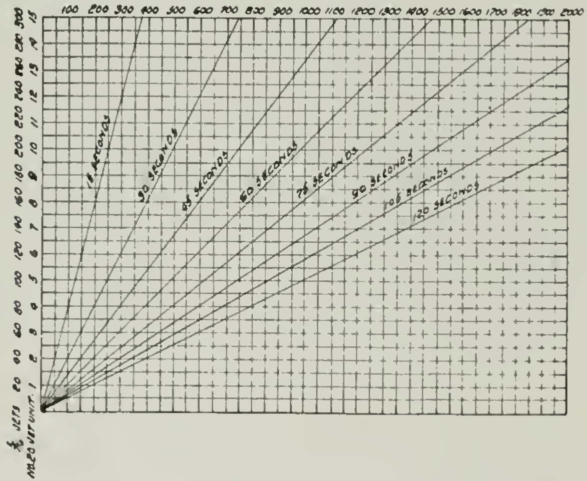


Fig. 4—Steam consumption per unit for boiler 21 tubes wide. Header pressure 100 lbs. when blowing. Valve open 15 to 120 seconds.

These charts have been compiled from data collected while making tests on soot blowers at one of the largest power plants in the United States under conditions which assure their accuracy.

LETTERS TO EDITOR.

Dear Sir:

Statement published in your Journal of January, 1922, as follows:

"A trial by Bury at Skinningrove Iron Works published immediately after the war, to recover the ethylene from coke oven gases in the form of alcohol by absorbing the ethylene in 6 deg. Be Sulphuric Acid, have not been realized on a commercial scale, although great expectations were expressed in responsible quarters. The heat economy of the process is so unsatisfactory that almost as many heat units must be spent as are recovered in the form of alcohol."

The facts are in quite opposition to this statement. The Skinningrove method, devised by Messrs. Bury, Ollander and Tidman for the recovery of alcohol, implements in every connection coke oven waste heat of no market value as against the expenditure of purchased fuel. It would only be true to state that if this heat had to be purchased, the recovery of alcohol would not be worth while. The process has not been abandoned as indicated in your Journal, although it has been delayed owing to the industrial upheavel during the past year in Great Britain, during which period the coking plants everywhere have been shut down.

Yours faithfully,

The Skinningrove Iron Co. Limited,
Ayna Hutchinson,
Managing Director.

Summer B. Ely, Prof. of Commercial Engineering,
Carnegie Institute of Technology,
Pittsburgh, Pa.

Dear Sir:

I have read with much interest in The Blast Furnace & Steel Plant Magazine, an abstract of your paper, "The Possibility of Improved Methods of Rolling Sheet Steel." The possibilities of a continuous sheet mill are indeed very interesting and no doubt will some day be realized.

You have given in your paper a description of a continuous sheet mill in the town of Teplitz in Northern Austria. This mill finishes 12 gauge sheets, 60 feet long and from 40 to 50 inches wide.

In connection with the rolling of 12 gauge plates or sheets I believe you will be interested to know about the Brier Hill Steel Co.'s 84 in. Plate Mill at Youngstown, Ohio. I was efficiency engineer at this plant and helped to work out some of the difficulties experienced in starting a new plant.

This is a tandem plate mill. The rougher is a two high motor driven reversing mill and is used in roughing down 3 in., 4 in. and 5 in. slabs. These slabs are then rolled, in a three high finishing mill, down to as low as 12 gauge. This mill is able to roll 12 gauge sheets, 36 inches wide and 40 or 50 feet long at the rate of 60 sheets an hour.

These sheets, however, on leaving the mill are buckled too much to make satisfactory sheets. This difficulty is entirely overcome by the use of a Hagan Costello Continuous Annealing Furnace. The sheets on passing through this continuous annealing furnace are heated to 1,600 deg. or 1,700 deg. F. and then are given three passes through cold rolls which makes sheets comparable to sheet mill product.

Many hundred of tons of sheet steel are rolled at this plate mill for automobile bodies, a product ordinarily considered a sheet mill product.

Very truly yours,

L. L. Darner.

NEWS OF THE PLANTS

The Hudson City Steel Corporation, 233 Broadway, New York, N. Y., is completing plans and will soon commence the erection of its proposed plant at Hudson, N. Y., where site has been secured providing an extensive acreage. The plant will consist of a series of six main buildings, each one-story, estimated to cost approximately $1,000,000, including machinery. The works will be used for the manufacture of a general line of steel products. Dwight P. Robinson & Company, 125 East Forty-sixth street, New York, is engineer for the project, and bids will be asked from this office.

The Eastern Steel & Wire Company, Newark, N. J., recently organized under state laws with a capital of $1,000,000, has purchased a tract of land on Evergreen avenue, near Frelinghuysen avenue, as a site for the erection of a new plant for the manufacture of general steel and steel wire products. A general building contract has been awarded to the American Concrete Steel Company, 27 Clinton street, Newark, for the erection of the initial plant unit, to consist of a main building 180x520 feet, and a number of smaller structures, estimated to cost approximately $300,000, including machinery and operating equipment. Ground for the plant will be broken early in April and it is expected to have the plant ready for service early in the fall. Contracts for the machinery will be awarded in the near future. E. A. Henry, formerly connected with the American Steel & Wire Company, Pittsburgh, Pa., is president of the new corporation.

The Pidgeon-Thomas Iron Company, Memphis, Tenn., has completed plans for the construction of a new steel fabricating plant for structural and other iron-working. It will be one-story, 165x260 feet, and is estimated to cost close to $75,000, including equipment. E. L. Harrison, Memphis, is architect and engineer in charge of the work.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., a subsidiary of the United States Steel Corporation, has all of its blast furnaces in operation, with production in other departments on practically a 100 per cent basis. It is said that this is the first complete steel plant attaining full production during the past 24 months.

The Pennsylvania Tank Line, Argentine, Kan., manufacturer of steel tank cars and affiliated steel products, has broken ground for the erection of a new plant at Augusta and Fortieth streets, Argentine, Kan., to consist of three buildings. These will be a one-story steel fabricating works, 80x100 feet, and two adjoining buildings, 80x100 feet, and 40x45 feet, respectively. The general contract for the structures has been awarded to the Kansas City Structural Steel Company. Headquarters of the company are at 25 West Forty-third street, New York, N. Y.

The American Steel & Wire Company, Worcester, Mass., has filed plans for the erection of an addition to its plant on Fairmount avenue, New Haven, Conn., to cost about $40,000. Improvements will be made also in the present building. The work will be placed under way at once.

The Carbon Iron & Steel Company, Parryville, Pa., is planning for the early resumption of production at its plant, which has been under curtailment for some time past. Improvements and repairs will be made to the main machinery and operating equipment.

The F. P. Smith Wire & Iron Works, Inc., 2346-Clybourn avenue, Chicago, Ill., has arranged for the erection of an addition to its plant for increased capacity. The new building will be three-story, 25x42 feet, and will be located at the rear of Clybourn and Chester avenues. A general building contract for the work has been let.

The Rhode Island Malleable Iron Company, Hillsgrove, R. I., has completed plans for the erection of a new one-story plant at Providence, R. I., and will commence construction at an early date. It will be 67x250 feet, located on Narragansett avenue, and will be equipped for general production.

The Trumbull-Cliffs Iron Company, Warren, Ohio, is maintaining continuous operation at its new blast furnace, recently blown in. High production averages are being secured, totaling close to 500 tons of material a week. The output is being used at the plant of the Trumbull Steel Company, of which the company is a joint subsidiary with the Cleveland-Cliffs Iron Company, Cleveland, Ohio.

The Cambria Steel Company, Johnstown, Pa., has recently resumed production at the open hearth furnaces at its local plant. At the Franklin works of the company, 16 furnaces are in operation at the present time, while plans are being perfected for the early resumption of production at the plant at Bessemer, Pa.

The Boston Iron & Metal Company, Pratt Street, Baltimore, Md., has recently acquired the plant of the C. A. Gambill Manufacturing Company, Ellicott City, Md., which has been in financial difficulties. The new owner has given a stated consideration of $410,000 for the property, and plans to utilize the works in connection with its general operations. Morris Schapiro is president.

The Youngstown Pressed Steel Company, Warren, Ohio, affiliated with the Sharon Steel Hoop Company, Sharon, Pa., has work under way on enlargements at its local plant for increased production. Additional equipment will be installed in certain departments of the works. It is expected to have the expansion completed and ready for operation at an early date.

The Swartz Manufacturing Company, Freeport, Ill., has been organized to take over and operate the business heretofore conducted by Charl H. Swartz, for the manufacture of iron products. A new shop building has recently been erected and will be used for general works expansion, particularly in the line of iron products for automotive service. Carl H. Swartz heads the new organization.

The Inland Steel Company, Chicago, Ill., is increasing production at its East Chicago, Ind., works, and has recently added about 1,000 men to the working force. The manufacture of steel rails has been resumed, and a number of the mill departments are now engaging on close to an 80 per cent basis. The company has secured an order from the Union Pacific Railroad Company for 350 tons of spikes, and also has booked a number of rail contracts.

The Ohio Steel Foundry Company, Lima, Ohio, has secured a large order for castings for the Argentine Republic, and has arranged for operations at a full capacity schedule at its local plant.

WITH THE EQUIPMENT MANUFACTURERS

NEW HAND POWER HOIST

Users of hand power hoists of five tons and larger capacity will be interested in a patented electric machine that may be suspended in the bight of the operating chain, having a capacity to overhaul 138 feet of hand chain per minute and chain pull of 130 pounds.

This gives a load lifting speed of approximately four times that obtainable by hand power and requires but one man for operation.

Current may be supplied by a flexible conductor from convenient sockets or suspended from the hoist if more desirable to bring feeders to that point.

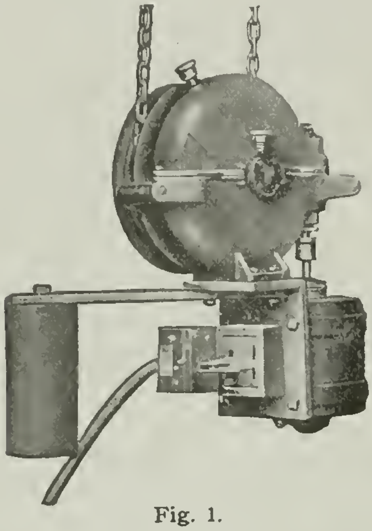


Fig. 1.

The machine balances itself, weighs about 160 pounds and is easily handled.

The gears are hardened and run in oil.

It can be furnished for operation on both alternating and direct current.

The machine is manufactured by the New Jersey Foundry & Machine Company, 90 West street, New York City, from whom more complete information may be obtained.

NEW GASOLINE POWERED LIFT TRUCK

A gasoline powered elevating platform truck embodying many unique construction features, to be known as the Clark Truklift, has been put in production by the Clark Tructractor Company, Buchanan, Mich., manufacturers of gasoline driven industrial trucks and tractors.

The Clark Truklift conforms in appearance and uses to the electric elevating lift trucks which have been used in industrial plants for many years, but low initial cost, ease of maintenance, flexibility, and continuous 24-hour service are distinguishing characteristics claimed for it by the builders, who are the pioneers in the manufacture of gasoline industrial trucks.

The loading platform is 26 in. wide by 54 in. long and will elevate its load of 4,000 lbs. from a minimum of 11 in. to a maximum of 16 in. from the floor in eight seconds; automatic stops provide for both up and down limits; elevation can be stopped by hand control lever at any point.

The lifting mechanism is operated by hydraulic pressure. Power for locomotion and elevating the load is derived from a 15 hp. 4-cylinder tractor engine with a 3⅛ in. bore and 4½ in. stroke. The engine is mounted at the rear in a closed compartment containing transmission, governor, vacuum tank, radiator, etc.

A three-point suspension is used, the steering wheel forks being supported in a steel casting which is pivoted at the center of the frame on a chrome nickel steel pin 2 in. in diameter. The drive is through a Clark bevel gear axle equipped with ball and roller bearings located under the loading platform. Driving wheels are cast steel with pressed on rubber tires 10½x5 in.; steering wheels are cast steel disc type with pressed on rubber tires 16x3½ in.

Standard automotive construction has been adhered to wherever possible so that the Truklift can be serviced by any good automobile or truck mechanic. The manufacturers claim as a very desirable feature the provisions that have been made for accessibility—a hinged hood renders the engine available for inspection instantly and if necessary the machine can be stripped down to the chassis in less than 20 minutes.

The driving and elevating controls are mounted on the rear of the engine compartment and are operated by the driver who drives standing. The brake lever pedal is under the driver's foot and so arranged that the Truklift stops automatically if for any reason the operator steps off while the machine is running.

The Truklift is the outgrowth of two years of development and testing work and is intended to meet the needs of those who require a full powered machine to work eight hours or more a day continuously in the transporting of materials in departmental or inter-plant haulage; it will climb a 10 per cent grade with a 4,000-lb. load and has two speeds in each direction.

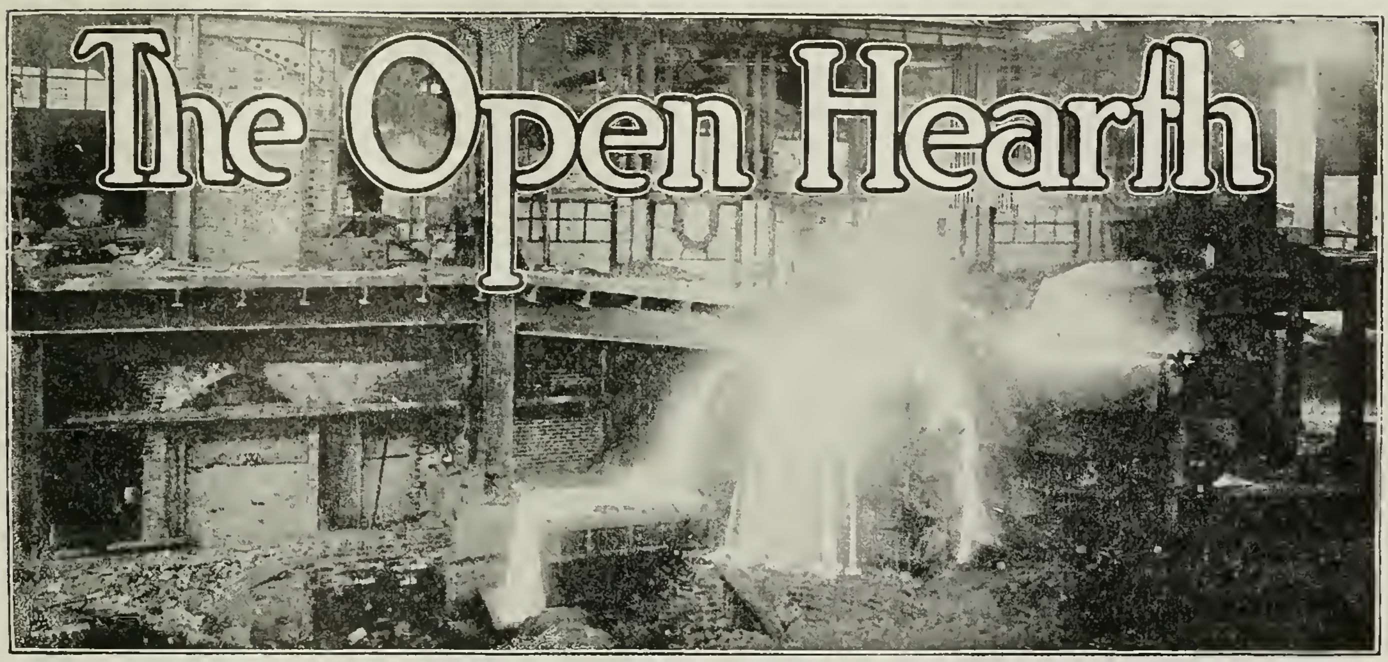
The total weight of the Truklift ready to go to work is 2,500 lbs.; over all length of machine is 107 in.; width 35½ in. and height 51 in.

WHEN "FREE AS AIR" LOSES ITS MEANING

Air when compressed and converted into a form of energy and power ceases to be "free"; fuel, machinery, equipment, and labor enter into making it an item of cost. And cost of compressed air greatly rises through any waste by leakage before final distribution to the tool which it operates or to the points of its ultimate use. Due to leakage through joints in piping, valves, split pipe, defective castings, and wastage at a tool or machine, the over all efficiency of compressed air is very often reduced 40 to 60 per cent throughout the system.

Jenkins Brothers, manufacturers of Jenkins Valves, have recently perfected and are now marketing a brass air gun, which is air-tight and an assurance against costly air waste. The Jenkins renewable disc with which this air gun is fitted is an innovation in equipment of this kind, and is especially suited for air service. The disc forms a perfect contact on the seat and takes up the wear of frequent usage. The disc gives long service, but can be easily and quickly renewed if necessary.

This air gun is finding wide use in foundries for blowing off cores, cleaning core boxes, flasks, patterns, and for general dusting. In machine shops for blowing off chip boring filings, trimmings, and for cleaning tools, taps, dies, etc.—and in wood working mills, textile mills, electrical stations, garages—everywhere that a blast of air is required.



The Open Hearth

Col. Arthur S. Dwight, New York, the new president of the American Institute of Mining and Metallurgical Engineers, is a leading figure in the Federated American Engineering societies. He is a graduate of the Columbia School of Mines, where he obtained his degree in 1885. Col. Dwight has been active in the Anglo-American movement to promote world peace through the cooperation of engineers throughout all countries. He is a former trustee of Columbia university and is secretary of the general committee of trustees, faculty and alumni of the Columbia School of mines. Col. Dwight was a member of the American mission which went abroad last summer to confer the John Fritz gold medal upon Sir Robert Hadfield in England and Eugene Schneider in France.

V V

Martin Harder has become affiliated with the South Side Malleable Castings Company, Milwaukee, Wisconsin. Mr. Harder was formerly superintendent of the malleable department of the Chain Belt Co., Milwaukee, and more recently connected with the Saginaw Malleable Iron Co., Saginaw, Michigan.

V V

C. D. Watson has opened an office at 407 Mahoning Bank Building, Youngstown, Ohio, where he will handle sheets and sheet mill by-products under the name of the Watson Bros. Steel Company. Mr. Watson was formerly vice president of the Sheet Metal Mfg. Company, Youngstown, Ohio.

V V

C. Rogers, formerly superintendent of the Michigan Gray Iron Casting Company, Detroit, has been made night superintendent for the Monroe Steel Casting Co., Monroe, Michigan.

V V

John McConnell has again become affiliated with the United Alloy Steel Corporation, Canton, Ohio, as vice president in charge of operations. He gained distinction in the early days of the United Steel Company, later merged in the United Alloy Steel Corporation, in producing the first vanadium steel in commercial quantities. His experience comprises ten years with the Carnegie Steel Company, three years with the Bethlehem Steel Company, eleven years with the United Steel Company when he was general superintendent, one year with the Central Steel Company as consulting metallurgist, and three years as vice president in charge of alloy steel production with the Interstate Iron & Steel Company, Chicago.

V V

The Westinghouse Electric & Mfg. Company recently announced several changes in the personnel. R. L. Rathbone, who has been manager of the Cleveland office, will take up special duties in connection with merchandising matters, with headquarters in Cleveland, and is succeeded by J. Andrews, Jr., who has been manager, industrial division, Pittsburgh office. R. Seybold has been appointed manager of price statistics and will act as secretary of the domestic sales committee. W. R. Keagy has been appointed manager of the Cincinnati office and J. R. Deering manager of the Los Angeles office. H. S. Walker succeeds H. E. Lanning as promotion man in the Denver office and I. G. Cline takes the promotion work vacated by R. A. O'Reilly in the Chicago office. K. L. Graham succeeds to the post vacated by H. C. Hopkins as promotion man in the San Francisco office.

V V

E. M. Griffiths, the founder of the Burton Griffiths & Co., Ltd., of London, England, has resigned his position as managing director and chairman of that business and has also retired from the board of the Birmingham Small Arms Co., Ltd., so that he is no longer associated with the control of either company. His city address is now 30-32 Ludgate Hill, London, E. C.

V V

Joseph H. Roberts, Midvale Steel & Ordnance Company, Nicetown Works, has resigned to become assistant to the president of the Electric Alloy Steel Company, Youngstown, Ohio.

V V

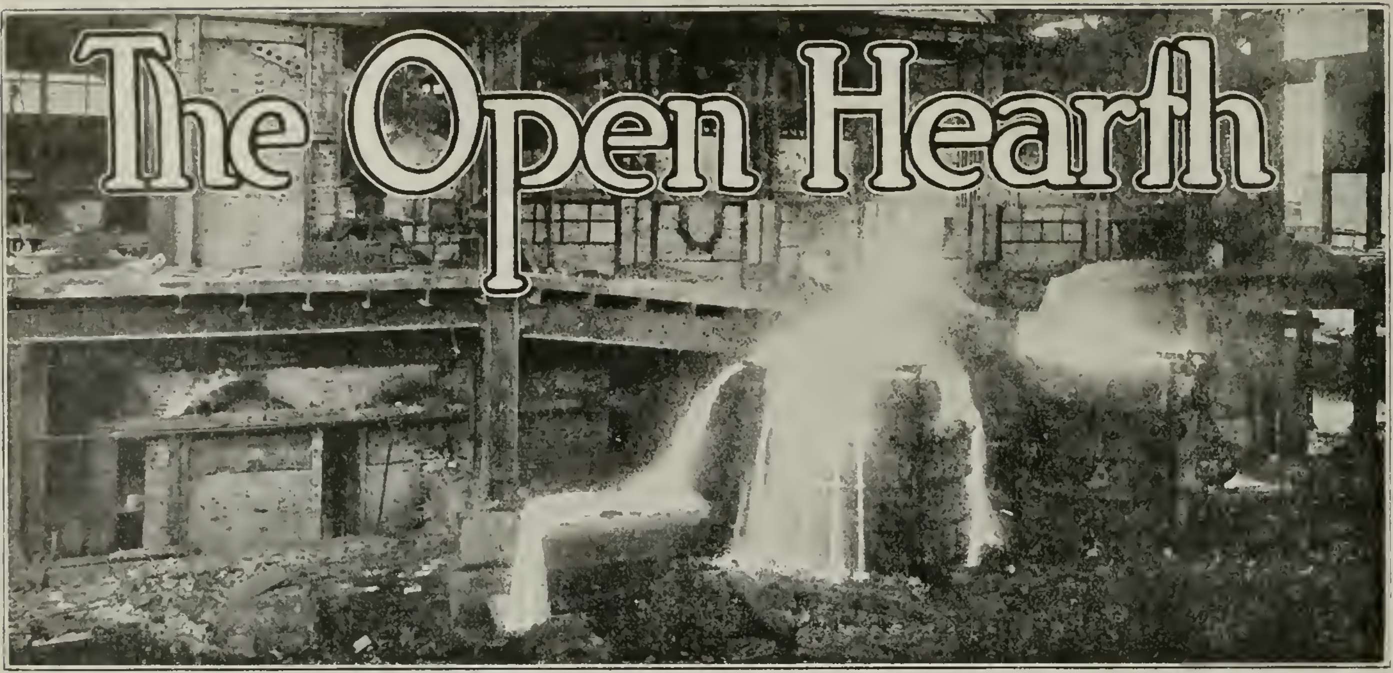
John F. Mazen has been appointed assistant general manager of sales of the Pittsburgh Steel Company, Pittsburgh, Pa. Mr. Hazen has been connected with the above named company for several years in the capacity of sales.

V V

Samuel E. Duff, consulting engineer, Pittsburgh, has been elected president of the Memphis Steel Construction Company, Magee Building, that city. For some time past has been that company's consulting engineer. He succeeds C. A. Hunt.

V V

Samuel R. Robinson recently resigned as foundry super-



intendent of the Sandusky Foundry & Machine Company, Sandusky, Ohio, to become metallurgist with the Lorain Foundry Company, Lorain, Ohio. Previously, Mr. Robinson had been metallurgist for the Philadelphia Roll & Machine Company, Philadelphia, and the Duquesne Steel Foundry Company, Coraopolis, Pa.

V V

J. C. Miller, Manager of the Columbus, Ohio, division of the American Rolling Mill Company, Middletown, Ohio, has been transferred to Ashland, Kentucky, as manager of the Ashland division, formerly the Ashland Iron & Mining Company which recently was taken over by the American Rolling Mill Company. In a recent organization of the Ashland Coal & Iron Railway Company, also owned by the American Rolling Mill Company, Mr. Miller was elected first vice president and general manager and his election as president of the Tygart Limestone Company, another subsidiary, also is announced.

V V

Thomas C. Ham, who has been looking after export business in the New York office of the Jones & Laughlin Steel Company, Pittsburgh, was on March 1st made assistant manager of exports under A. H. Holliday, manager of exports. He will remain in the New York office. Mr. Ham was born and raised on a New Hampshire farm and is a graduate of Dartmouth college. His first employment in the steel industries was with the American Steel & Wire Company as manager of its office in Oklahoma City from which he was promoted to assistant manager of the merchant trade department at the Chicago office. He went to the Jones & Laughlin Company in 1910 as assistant to the manager of sales of the wire department. During the war he was engaged in the promotion of all the Liberty Loan drives in Pittsburgh. Following this he was assigned to the New York office to look after export business.

V V

Robert C. Stanley, who was recently elected president of the International Nickel Company, is taking his new position with the responsibility of finding new uses for nickel. This is a particular need because of the effect of the disarmament agreement upon the consumption of nickel in armor plate. The company's development work will be consolidated and directed intensively. Mr. Stanley has spent his entire business career with the International Nickel Company. He became assistant superintendent of the American Nickel Works at Camden, N. J., when that company was taken over from Joseph Wharton on the formation of the International Nickel Company in 1902. He subsequently became superintendent in charge of that plant and his next step was to become assistant general superintendent of the refinery at Constable Hook, N. J., later becoming general superintendent. In 1918 Mr. Stanley was made first vice president of the company, in full charge of all operations in this country and Canada. He was elected president March 1st. He was graduated from Stevens Institute in 1899 with the degree of mechanical engineer and from Columbia School of Mines in 1901.

V V

A. H. Murphy, superintendent of the American Rolling Mill Company plant at Zanesville, Ohio, has been promoted to be plant manager and W. R. Barnett, assistant superintendent, has succeeded Mr. Murphy.

V V

G. M. Black, formerly blast furnace superintendent of the Alan Wood Iron & Steel Co., Swedeland, Pa., will leave for Spain about April 1st where he will become connected with the Compania Siderurgica del Medittcrraneo, as superintendent in charge of blast furnaces.

V V

C. D. Claney was recently elected secretary and treasurer of the Superior Steel Corporation, Pittsburgh, at its recent annual meeting in New York City. Mr. Claney was formerly affiliated with the Crucible Steel Company of America, Pittsburgh. As secretary, he succeeds H. D. Sarge who resigned recently as secretary and assistant treasurer. At that meeting, President E. W. Harrison was re-elected and E. H. Forster, formerly vice president and treasurer, was re-elected vice president. Donald M. Liddell was re-elected assistant secretary and assistant treasurer.

V V

William H. Weichsel recently resigned as superintendent of the Dover, Ohio, mill of the American Sheet & Tinplate Co., effective April 1st, to become manager of the Inland Steel Company works at Indiana Harbor, Ind. Mr. Weichsel has been superintendent at Dover since 1916. W. H. Ashbaugh of Leechburg, Pa., has been appointed to succeed him.

Some Pointers on By-Product Coke Oven Operations

HANDLING OF A COKE OVEN PLANT DURING A DISPUTE

In an inaugural address to the North of England Branch of the Coke-Oven Managers' Association, Mr. A. H. Thwaite dealt with three methods to be adopted during a dispute, viz., drawing only enough ovens to maintain gas supply for heating the oven walls, beehive by-product coke ovens, and the total shutting down of ovens and plant, leaving hot coke in the ovens.

In respect to the former, advantages would be in keeping the oven heats such, that the remainder of the battery could be rapidly restarted upon resumption of work, thus avoiding hand-firing or beehiving, and reducing serious contraction of brickwork. On the other hand, there is risk of not maintaining an adequate supply of gas; expense in disposing of the coke, loss in benzol, and difficulty of procuring labor, are other disadvantages.

Apropos the second method, carbonization could be extended over a longer period, heats could be rapidly increased, and there would be no serious contraction of brickwork. As a set-off, however, the coke, which would not always be good, would be expensive to stock, and there would be a serious loss in by-products, and risk of damage to the brickwork.

In shutting down, any advantages would depend on whether arrangements were made for flues to take gases direct from the ovens into wall combustion flues, thence to the main flue and chimney. Hand-firing would be essential, but would have its attendant dangers, and although advantages would be the saving of coal and by-products, more economical as regards labor, power, and facilities for repair, against same there would be the loss of coke, labor cost for hand-firing, and contraction of brickwork.

It is suggested that the most economical way would be to erect suitably designed gas producers, equipped with mechanical means for charging fuel, etc. Only a small quantity of hot coke would be necessary to enable rapid restarting, and although the capital cost might be heavy, it would soon be recompensed as compared with the expenses for hand-firing on the three previous systems mentioned.

BUREAU OF MINES INVESTIGATES USE OF VARIOUS COKES IN BLAST FURNACE

The blast furnace research section of the Bureau of Mines, located at Minneapolis, has carried out plant investigations for six years; these are being continued. The conviction has been forced on it, however, that little progress toward the solution of the many important problems involved in furnace operation will, or can, be solved by any method of study of commercial operations on account of the large amount of materials to be handled and the numerous causes of irregularities. The need of a furnace capable of operating on a small scale and under controllable conditions has been obvious for years. In the last year an experimental stack has been erected and 12 combinations of furnace lines and operating conditions tried out. This work is being continued.

One investigation covers the effect of furnace lines on blast furnace operations. The blast furnace works on the countercurrent principle; the ascending gas stream encountering the descending raw materials, with a regenerative transfer of heat. Maximum contact between gas stream and raw materials produces most rapid heat transfer and reduction of the ore. The degree of contact between gas stream and solid charge depends to a very large extent upon the size and shape of the furnace. About 200 furnaces are relined each year, most of the new lines being copies of previous unsatisfactory ones. The furnace designer, lacking practical rules governing the best shape of furnace, prefers to stick to known troubles rather than accept the risk of a new design. An investigation in the laboratory and in the experimental furnace is being carried on by the bureau with the hope to discover some fundamental principles which may be of use to the furnace designer.

Another investigation being conducted relates to the effect of physical characteristics of the charge on blast furnace operation. Probably the greatest cause of the fundamental inefficiency of the blast furnace, considered thermally as a furnace, is due to the enormous disparity between the sizes of the particles of the solids charged. The average lump of coke has a volume of 400 to 800 cc. and a surface exposed to the gas stream of 0.5 to 1 sq. cm. per gm. The average ore particle, on the contrary, has a volume approximately 0.000005 and would expose a surface of about 300 sq. cm. per gm. to the gas stream if its surface were exposed to the gas stream. A study is being made of the effect on furnace operation of a mixture of solid particles one-third of which is one hundred million times the size of the other two-thirds. In a number of cases furnace operators have improved furnace efficiency by sizing the coke charge. There are prospects of being able to continue such work on the sizing, not only of the coke but of the ore.

The bureau is also conducting performance tests on various cokes in the blast furnace. Opportunities for obtaining rather complete data on coking conditions and co-ordinate information concerning the performance of this coke in the blast furnace are particularly good at this plant. Variations in the quality of the coke in commercial practice are sufficiently great to promise valuable data without instituting special coking conditions. Furnace irregularities from other causes probably will be difficult to eliminate. Chances of a successful study of data at this plant are better than at the majority of plants due to the simple and direct means there employed for the transfer of coke from the ovens to the furnace. In most plants the identity of individual coke heats is lost in transfer and storage of the coke.

COAL AVAILABLE IN CASE OF STRIKE

An analysis of the coal situation, the purpose of which is to give business men information regarding possible fuel supplies in the event of a strike of miners on April 1, has been issued by the Coal Bureau of the Natural Resources Department of the Chamber of Commerce of the United States. The bulletin carries charts covering conditions in particular localities.

As the anthracite field is 100 per cent unionized, all supplies in the event of a complete closing of the mines will have to be drawn from stocks on hand. Reliable figures on which to base an estimate covering possible anthracte supplies in the event of a strike completely closing the mines are not available.

Assuming this year's bituminous consumption to be comparable to that of 1921, 7,600,000 tons per week, the supply from non-union fields would fall short 3,600,000 tons per week of meeting the demand.

TRADE NOTES

The County Gas Co., of Atlantic Highlands, N. J., has determined upon comprehensive improvements to its plant and to that end has awarded the contract for the entire work to The U. G. I. Contracting Co., of Philadelphia. In general, the improvements will include remodeling of all of their water gas apparatus, including the installation of new generators and air and steam controls. There will also be installed a new turbine blower plant with blast main system, 300-H.P. water tube boiler, take-off main, exhauster and connection, together with a building for same, Venturi meter, 50,000 gallon capacity oil storage tank and steel purifier 21 ft. diameter by 16 ft. 4 in. high. Necessary pipe connections are included for the various apparatus.

Mr. Noel Cunningham, formerly connected with the Coal Washing Equipment Co. has now become associated with the Hardinge Company, Incorporated, 120 Broadway, New York, N. Y. This change is due to the acquirement by the Hardinge Company of all manufacturing and sales rights of the James Coal Washing Equipment, formerly handled by the Coal Washing Equipment Co.

The condenser and purifier systems at the South Bend Works of the Northern Indiana Gas & Electric Co. are to be enlarged and remodeled. The contract for this work has been awarded to The U. G. I. Contracting Co., of Philadelphia. This Company has also received the contracts for installing scrubber condensers at the Frankfort, Ind. and Peru, Ind. plants of the same Company.

Freyn, Brassert & Company, Chicago, have been retained by the Trumbull-Cliffs Furnace Company in connection with extensions to electrical power output at the Warren Blast Furnace Plant; by the Kailan Mining Administration, China, as consultants in concentration and mill tests on their low grade magnetic ores.

The Orton & Steinbrenner Co. of Chicago and Huntington, manufacturers of locomotive cranes, clam shell and orange peel buckets and coal crushers have made arrangements with J. Ross Bates, formerly connected with Wonham, Bates & Goode Trading Corp., of N. Y. and Boston to represent them in the New England States and New York City. Mr. Bates has offices at 136 Liberty St., New York City and 128 School St., Watertown, Mass.

The Diamond Soot Blower business has been purchased by new interests in the form of the Diamond Power Specialty Corporation of Detroit, Mich., a new company which has taken over the business and plant of the Diamond Power Specialty Co., co-partnership, the members of which are retiring from the soot blower business in the Western Hemisphere. Mr. Norman L. Snow, President and Treasurer of the new company, resigns his position as Vice President and active head of the Terry Steam Turbine Co. of Hartford, Conn., with whom he has been connected for the past thirteen years. Mr. Snow is a graduate of Yale Scientific School and Massachusetts Institute of Technology, and has been in the power plant field for the past eighteen years.

The Gas Combustion Company of Pittsburgh, Pa., have recently filled its fifth repeat order for Bradshaw burners at Jones & Laughlin Steel Company, Aliquippa Works at Woodlawn, Pa. This plant is now completely equipped with Bradshaw Patented Blast Furnace Gas Burners. The Gas Combustion Company also recently equipped three (3) 250 H.P. Cahall boilers at New Castle Steel Works and Furnaces, New Castle, Pa., with Bradshaw Patented Blast Furnace Gas Burners.

Whiting Corporation established their own branch sales office in New York City at 136 Liberty St. (Phone Rector 9825), having discontinued their agency agreement with Wonham, Bates & Goode Trading Corp., N. Y., who formerly represented us in the East. Mr. J. Ross Bates, now a Vice President of Whiting Corp., is in charge of the new office. He will be assisted in the New York territory by Mr. D. Polderman, Jr., and in the New England States by R. C. Maley, who will open an office at Springfield, Mass. All of these gentlemen were formerly associated with Wonham, Bates & Goode Trading Corp.

The Union Steel Casting Company of Pittsburgh has purchased at private sale a large block of capital stock in the Pittsburgh Rolls Corporation of the same city. The plants are both located in the Lawrenceville District, and it is the intention of the Union Steel Casting Company in making this purchase that the two companies shall work in close harmony, and that no changes whatever be made in the local organization or management of the Pittsburgh Rolls Corporation, other than certain directors who will be retired by reason of the purchase will be replaced by officers of the Union Steel Casting Co.

The Pitsburgh Rolls Corporation (Phoenix Roll Works) has operated in the same locality for over 50 years. It was first under the name of Bowman, Boyd and Bagley, then as James B. Young & Company, and later as Seaman Sleeth and Company, who operated for a great many years, being succeeded in 1917 by the Pittsburgh Rolls Corporation. During all these changes the plant has been known as the Phoenix Roll Works; and Phoenix Rolls are familiarly known by every rolling mill in the United States, and generally throughout the world. The present officers are D. L. Eynon, President; Q. S. Snyder, Vice President and Treasurer; P. M. Fleming, Secretary. The Union Steel Casting Company was organized in 1899, and has grown from a very small beginning to one of the leading steel foundries in the country. The officers are C. C. Smith, Chairman; J. P. Allen, President; J. B. Henry, Vice President and General Superintendent; S. H. Church, Vice President; G. W. Eisenbeis, Treasurer; W. C. Eichenlaub, Secretary.

TRADE PUBLICATIONS

The Damascus Tool Company have issued a very attractive catalogue descriptive of "Damascus Tools." Complete information of the company's products which consist of rivet sets, punches and dies can be obtained from this booklet. It will be sent upon request to the company.

The Morgan Engineering Company of Alliance, Ohio, have issued a new "Soaking Pit Crane Bulletin" which is very interesting. It is well illustrated with views showing a number of Morgan installations in steel plants.

The Surface Combustion Co. of New York announce that they now have ready for distribution "No. 3D on Surface Combustion Low Pressure Air-Gas Inspirators. These inspirators are designed so as to be readily applicable to any make of gas furnace.

The H. K. Porter Co. of Pittsburgh, Pa., have issued an exceptionally interesting catalogue descriptive of "Porter Fireless Steam Locomotives." This locomotive is an innovation which has proven its value. It is a steam locomotive without boiler and firebox. In place of a boiler, it carries a tank containing water which is heated by steam from a suitable stationary boiler. It is ideal where trips are too infrequent and too irregular to justify the expense of a steam locomotive of usual type.

The Ideal Electric and Manufacturing Company of Mansfield has just issued two very complete bulletins, one describing their Alternating Current Motors and the other their Direct Current Motors. Either will be sent upon request.

The U. P. C. Book Company announce a new book published February 1st, 1922. "Best's Burning of Liquid Fuel." It is a practical treatise on the perfect combination of oils and tars, giving analyses, calorific values and other data.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., MAY, 1922 No. 5

Industrial Possibilities of South Will be Revealed at Meeting of Engineers

Spring Meeting of the American Society of Mechanical Engineers to Be Held in Atlanta May 8-11—Steel Mills and Foundries to Be Inspected in Birmingham, and Muscle Shoals Will Be Visited.

THE industrial resources and possibilities of the South are not generally understood. It is exceptionally fortunate, therefore, that the 1922 A. S. M. E. Spring Meeting is to be held in Atlanta, with excursions to other Southern cities, offering an excellent opportunity for the members of the Society to study at first hand the resources and meet the engineers and manufacturers of this section. In its future growth, the South will need the engineer and especially the mechanical engineer, the servant and master of industry. It can be confidently asserted, therefore, that as the industries grow, so will the strength and activity of the South increase.

In 1920 the South manufactured about one-sixth of the products of the United States. It had nearly one-half of the active cotton spindles and three-sevenths of the active cotton looms of the country and it used five-eighths of the cotton fabricated. About one-ninth of the pig iron of the country was manufactured in the South. One-third of the corn, over one-fifth of the wheat and about one-seventh of the oats were produced in the southern states. One-fourth of the coal of the country and about one-tenth of the iron came from south of the Mason-Dixon Line.

These figures indicate that already the South occupies an important industrial position, but studying recently published statements of resources we find that the future is even more encouraging. All of the bauxite, turpentine, sulphur and phosphate rock of the country is located in the South. They also have 60 per cent of the country's natural gas, 57 per cent of the petroleum, 50 per cent of the lumber, 45 per cent of the lead, 26 per cent of the coal and 10 per cent of the country's iron ore.

In view of the above facts we feel that the A. S. M. E. made a very wise selection in choosing Atlanta as its meeting place, and from the technical program outlined the meeting should be a very valuable one to attend. Seven of the sessions have been planned by the Professional Divisions of the Society and the strength of these new organizations is well shown in the fine programs that have been prepared. The mornings will be given over to the technical sessions, which will start at 9:30 a. m.

Many interesting inspection trips have been arranged for the visitors. While in Atlanta the plant of the Atlantic Steel Company, which is described in another section of this issue will be inspected.

The visit to Birmingham will be made on May 12, the day following the Atlanta meeting, and the party will go to Birmingham by sleeper from Atlanta. Headquarters have been arranged for at the Hotel Tutwiler, from which the inspection parties will leave at 9:30. Visitors may select between a visit to the foundry of the American Cast Iron Pipe Co. or to the by-product coke ovens of the Sloss-Sheffield Co. Both parties will meet at the Ensley plant of the Tennessee Coal, Iron and Railroad Co., where the blast furnaces, open-hearth furnaces, blooming mills, rail mills and power house will be inspected. Lunch will be served in this plant. Leaving the Ensley plant, the guests will be taken to the Fairfield plant of the T. C. I. & R. R. Co., where they will have the opportunity to inspect an entirely electrically driven plate and structural mill. This plant is also used for the manufacture of railroad cars, both of steel and wood. In the evening there will be a dinner at the Hotel Tutwiler.

Special accommodations have been arranged to visit Muscle Shoals on May 13th.

In view of the fact that so much attention has been drawn to the Southern steel plants by the holding of the spring meeting of the A. S. M. E. in Atlanta, we considered that it would be apropos to install a description of several of these plants in this issue. Accordingly a description of the plant of the Atlantic Steel Company of Atlanta will be found on page 252 and a description of the Alabama City plant of the Gulf States Steel Company on page 254. It is indeed interesting to note from these descriptions that the plants of the south are equal in every engineering respect with our finest northern plants.

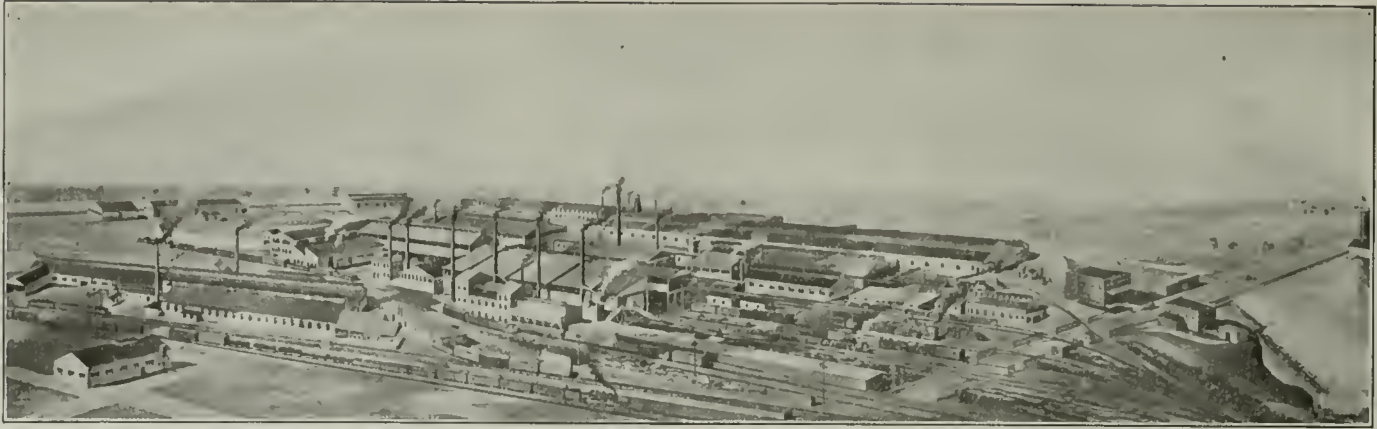


Fig. 1—Panorama view of Atlantic Steel Company, Atlanta, Ga.

Description of the Plant of the Atlantic Steel Company, Atlanta, Ga.

One of the Features of This Plant Is the Use of Powdered Coal for Firing One of the Open Hearth Furnaces and for Heating Purposes in the Soaking Pits—All Equipment Used of Modern Type.

THE Atlantic Steel Company is located just outside the city limits of Atlanta, Georgia, with local connections to all railroads leading out of the city. The well known shipping facilities of Atlanta is a distinct asset to the customer, shipments leave the yards within a few hours after receipt by the various railroads. In addition to the facilities of the city, the plant is equipped with every possible means of expediting an order. The warehouses have ample trackage while the yard has been laid out with the one end in view of prompt shipment. The plant transportation consists of locomotives, steam and electric cranes, conveyors, etc. The mills are located so that the raw material moves in one direction from start to finish, and orders for special material as well as standard stock are finished for shipment in the shortest possible time. Especial attention is given to packing export orders so that these reach the dock in record time. The products of the company commend themselves to the industries of the Southeast, especially to the cotton, turpentine and general agricultural interests. However, special orders within the capacity of the mill are handled with the greatest possible dispatch. In general the products are, rods in coils for rivets and for drawing wire, round and square bars in bundles, corrugated and twisted concrete reinforcing bars, heavy and light wagon tire, horseshoe stock, cotton ties and buckles, hoop steel for all purposes in coils or bundles. Nail wire, annealed black wire, galvanized wire, hog and cattle barbed wire, light and heavy, staples for barbed wire and poultry netting, field fence for poultry and live stock, common nails, flooring nails, roofing nails, slating nails, lathing nails, shingle nails, dowel pins, hoop fasteners, all of which receive the same scrupulous care in all processes of manufacture.

The steel made by the Atlantic Steel Company is melted in open hearth furnaces from pig iron and scrap. The proportion of the raw material depends, of course upon the quality of steel that is required. The three Morgan furnaces now in use are 38 ft. x 13 ft. x 7 ft. and have a maximum capacity of 60 tons per heat. Two of these furnaces are fired by gas from six Hughes gas producers 8 ft. 6 in. in diameter. The furnaces are of stationary reversing type with gas sewers 4 ft. 6 in. x 7 ft. 8 in. size, and stacks 5 x 130 ft. The third furnace is fired with pulverized coal. The coal for this furnace is dried to at least 1 per cent moisture content before pulverizing in a Fuller mill. The fineness is 96 per cent through a 100-mesh screens and 85 per cent through a 200-mesh screen. This pulverized coal, with a proper air mixture, is as inflammable as gas, and furnishes a better flame so that the time of melting in this furnace is as much as 30 per cent less than the time in a gas fired furnace. However, great care must be exercised in the selection of coal used, as a high sulphur coal will tend to make a high sulphur steel, but by proper care steel of equal quality may be secured.

The intensive heat of these furnaces, especially the direct coal fired furnace, necessitates an extensive system of water cooling of the furnace walls, doors and door frames, etc. The slag line on both the front and back walls is heavily piped as well as skewbacks and bullseye and an unusual feature is the piping in the uptake of the coal fired furnace, which adds extensively to the life of the furnace. The scrap, pig iron, limestone and refractories are hauled up an incline railway to the furnace floor level in standard W S M charging cars and pans. These are charged into the furnaces by a W S M 5-ton charging car which is an electrically operated floor track machine. During the charge the doors are raised and lowered by hydraulic pressure.

The melted steel when properly mixed is poured into a ladle of sufficient size to take the entire melt and from there poured into ingot molds which are set up on stools on permanent foundations. After they have sufficiently solidified the ingots are removed from the molds, usually by lifting the mold off the ingot, but in case the ingot sticks it is pushed out of the mold by an inclined hydraulic stripper of the Allen-Lang type. Each open hearth furnace has attached a Babcock & Wilcox three-pass double bank water tube waste heat boiler of 500 hp., equipped with a No. 6 Green fan running at 950 rpm. The reversing is made every 20 minutes by means of a 32-in. Forter valve, and a 42-in. mushroom air valve.

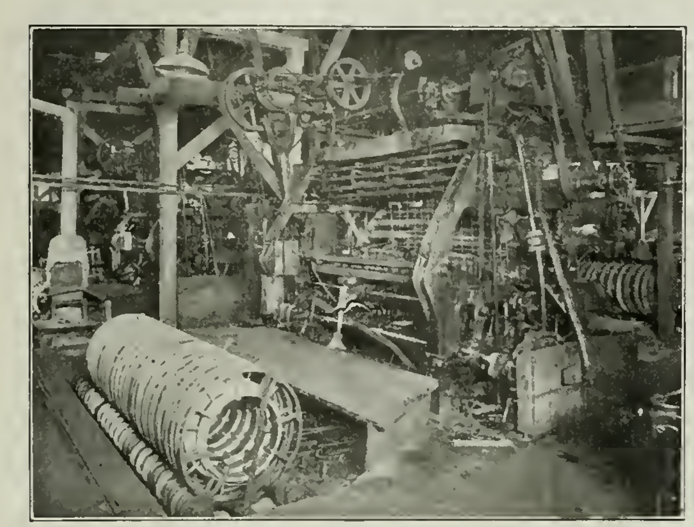


Fig. 2—View of field fence machine.

The soaking pits, which are eight in number, are fired with pulverized coal and are arranged in pairs with two pairs connected to a 4x90 ft. stack. These pits are 12 ft. 9 in. by 5 ft. by 9 in. deep. The cover doors are carried on a frame supported on wheels that roll on a horizontal track and when closed just clear the top of the pit walls. Part of the air furnished for combustion enters through a 12 in. pipe at 1½ lbs. of water pressure. The coal falls into this current of air and is carried into the combustion chamber by it. Additional air to complete combustion enters through openings in the wall of the combustion chamber. Control of the air, coal and cover doors is all from the pulpit just above the charging level running along the battery of pits. Each pit can be controlled separately from all the others and economy of operation kept uniform. The arch over the combustion chamber and the division walls are water cooled. Provision has been made for future utilization of the waste heat from these pits.

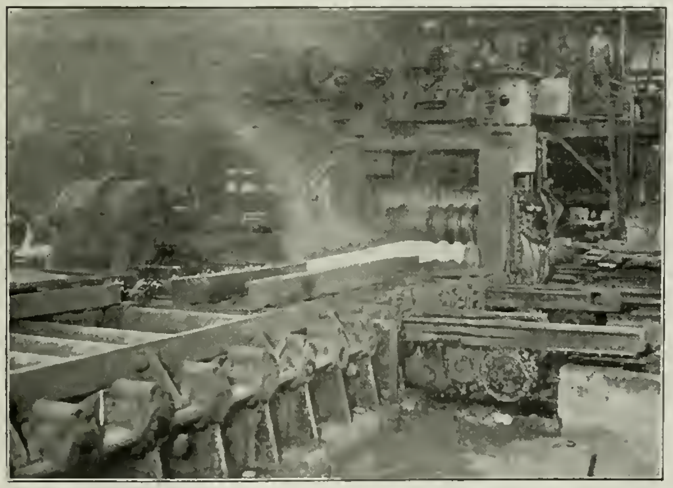


Fig. 3—View of blooming mill.

The ingots are brought to the soaking pits on a roller table, being weighed on scales in this table before charging. The charging and drawing is done by the same stiff legged crane. Two rows of ingots are placed on end in each pit so that the heat from the combustion chamber passes around each ingot. The heating process takes from three to four and one-half hours, depending on whether hot or cold ingots are charged.

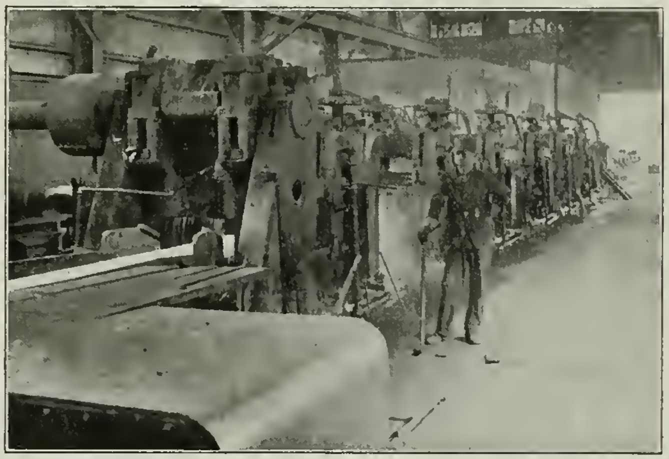


Fig. 4—View of continuous billet mill.

The blooming mill is 25x60 ft., made by the Mesta Machine Company, operated by a 2200 to 5000 hp. dc. Westinghouse reversing motor. Maximum speed 80 rpm. The ingots are reduced from 12x14 to 4x4 in 19 passes. The control is handled by three men in a cage above the roll table. Manipulator is operated hydraulically and the screw-down by motor. The Morgan continuous billet mill takes the 4x4 bloom and rolls it to a 1½-in. billet in six passes, 1¾ in. in five and 2 in. in four passes. These are cut into 30-ft. length billets by a flying shear and cooled on an 18-step cooling bed with capacity for 18,000 pounds. From the scales the billets are taken to the various finishing mills.

Fig. 5—View of rod mill rolling No. 5 rods.

The rod mill proper is a Morgan semi-continuous mill finishing a No. 5 rod in 14 passes from a 1½ billet weighing 7 lbs. to the foot. The continuous mill consists of six stands which delivers a 7/16-in. square. The other eight passes are handled by four men and two repeaters. The mill consists of the six-stand continuous mill two stands of 10-in. rolls, two stands of 9-in. rolls and two stands of 8½-in. rolls on four shafts, driven by a Corliss engine, at present 1800 hp., to be motorized in near future. The rod mill furnace is Morgan construction continuous type, built to take a 30-ft. billet. This furnace is gas fired, has three arches, the air for combustion is preheated by passing under sloping furnace bed. The billets enter at the upper end of incline and the pusher moves entire bed of billets down as each billet enters. The billets are pushed out directly into the continuous mill by a steam actuated clamp, belt driven pusher. The reels are belted from the engine while the conveyor is motor driven and speeded so that it takes five minutes to deliver a bundle of rods from the reels to the truck. The cooling bed for merchant bar holds 250-ft. pieces. The limits of the mill are 1⅜-in. round plain to ¼ in. on the cooling bed and ½ in. to No. 5 gauge rods in reels.

In addition to the above hot mill there are two hoop mills electrically driven and fired by coal direct. Capacity from 3x7/32 in. to ⅝ in. x No. 20 gauge, and a railroad spike mill with two automatic machines cutting ½ in. to ⅝ in. stock and a hand fed machine cutting 5/16 in. to 9/16 in. stock. The wire mills consist of a 50-block wire mill with cleaning tanks and baking ovens finishing wire from ½ in. to No. 18 gauge. Galvanizer capable of handling No. 2 gauge to No. 18 gauge. Barbed wire mill capable of making No. 12 gauge to No. 14 gauge wire, 4 in. to 6 in. spacing, two and four point and smooth twisted cable up to No. 10 gauge. Nail mill making all standard shapes of nails and spikes from 9 in. x 5/16 in. to ¾ in. x No. 17 gauge. Field fence, making field and poultry fences from 26 in. to 60 in. high.

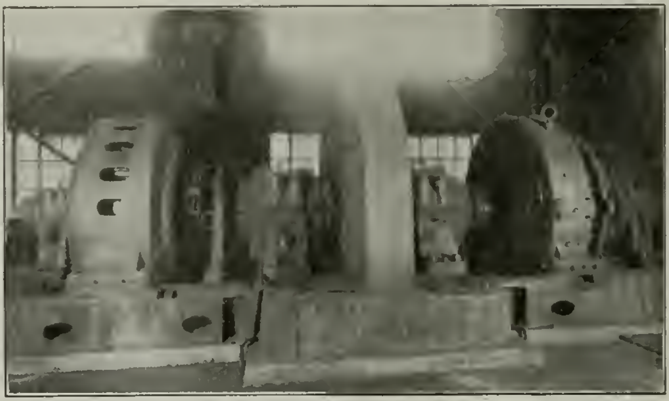


Fig. 6—View of rotary converter—blooming mill.

Description of the Alabama City Works of the Gulf States Steel Company

This Company Owns Plants and Properties Which Constitute an Integrated Steel Operation from Raw Materials and Fuel to Finished Product Consisting of Wire, Nails, Fencing and Bars.

THIS plant is located midway between Chattanooga, Tennessee and Birmingham, Alabama, at Alabama City, in a healthful, agricultural country. The climate is exceptionally moderate, making the labor conditions attractive.

The plant consists of the following units:

By-Product Coke Plant with Benzol recovery.
Blast Furnace.
Open Hearth.
Blooming Mill.
Merchant Bar Mill.
Rod Mill.
Commercial Wire Mill with various departments.

The plant is served by the Southern Railway, the Louisville & Nashville Railway and the N. C. & St. L. Railway.

The ground plan follows:

There are approximately 160 acres under fence with 80 acres adjoining held in reserve for future needs. Just outside of the plant inclosure are located 160 houses for employes together with large and complete Y. M. C. A. club house, commissary store, etc.

A description of the various units follows:

By-Product Coke Department:

This plant consists of one battery of 37, 12¼ ton, Koppers' cross regenerative by-product coke ovens. Capacity 500 cu. ft. which with crushed coal averaging approximately 55 pounds per cu. ft. gives an average charge of 13½ tons per oven. The oven chambers are 37 ft. long, 9 ft. 10 in. high and have an average width of 18¼ in.

The oven machinery consists of one Wellman-Seaver-Morgan combination pusher and leveler and door lifting machine. A standard type coal charging larry car operated by one D. W. Crocker-Wheeler 25 hp motor with hand operated standpipe swabbing machine, conveys the coal from a 700-ton bunker, across a standard railroad track scale, where each charge is carefully weighed. A 20-ton General Electric Company mining type locomotive with two quenching cars receive the coke from the ovens and take to quenching station. After being quenched the coke is dumped on to a Robins inclined wharf. From this the coke is fed by a rotary feed onto a 42 in. rubber, canvas conveyor belt, which delivers the coke to a 36 in. incline conveyor, then across a bar "grizzly" where the braize is screened out, the remaining coke being loaded into cars for the blast furnace.

The coal is received from the company's mines in dump cars, which are unloaded at a track hopper from which it is delivered by the usual shaker pans and pan conveyor to a 30 in. conveyor and thence to a revolving Pennsylvania Crusher Company Bradford breaker or cleaner where refuse coal is separated. The cleaned coal passes into two so called "mixing bins," capacity 200 tons each, and from there to mixing conveyors and into the Pennsylvania Crusher Company's hammer mill where a coal fineness of approximately 80 per cent through ⅛ in. mesh screen is maintained. The crushed coal is delivered to a 24 in. conveyor and finally to the 700-ton bunker over the ovens.

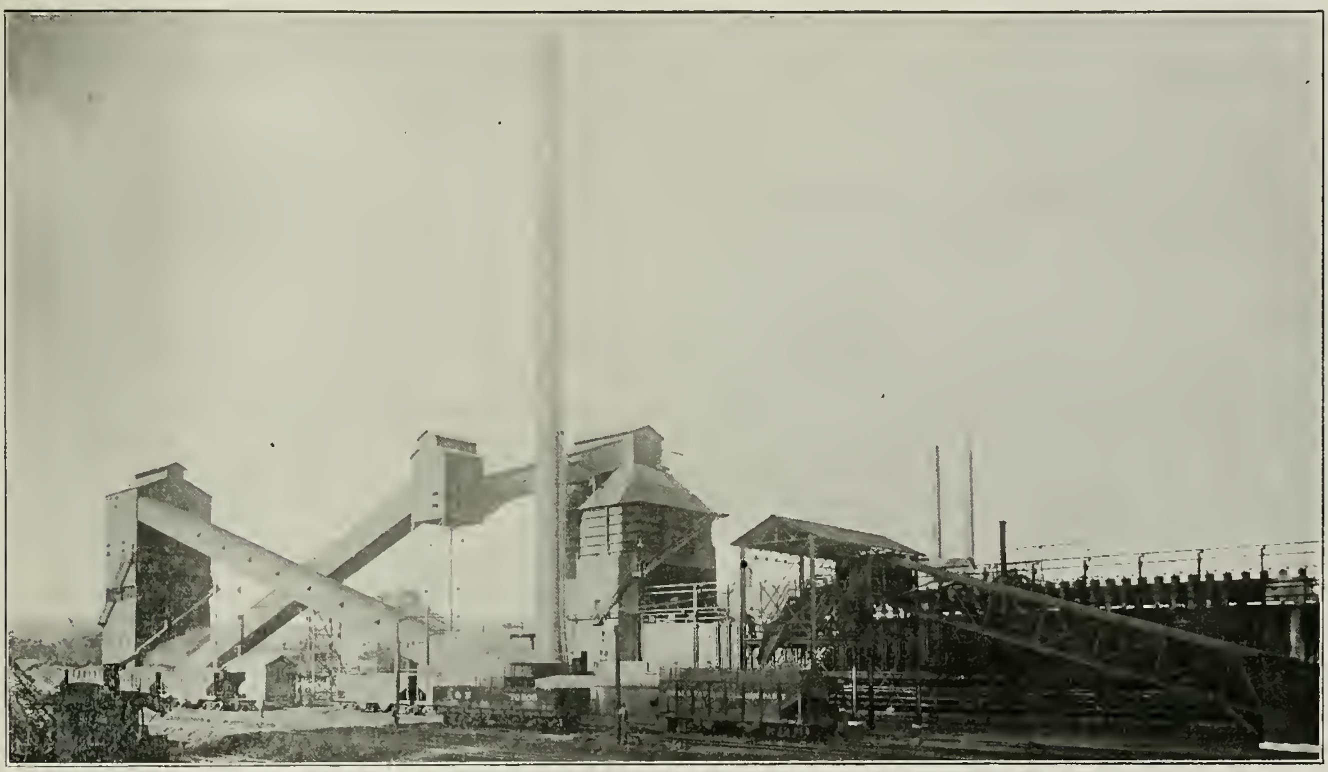


Fig. 1—View of by-product coke plant.

All coke and coal handling machinery, conveyors, etc., are of the Robins Company type.

Two Connersville positive type gas exhausters driven by Ball vertical non-condensing steam engines (one unit being in reserve) handles the gas from the ovens to the primary coolers and thence into the By-Product building where the gas is freed from the tar by P. & A. extractors and then through reheaters, thence through saturators (lead lined) for ammonium sulphate. A 5-ton Morgan electric crane handles the sulphate stock either from pit or into box cars for shipment.

The wash oil is handled by the usual circulation pumps, tanks, superheaters, etc. The continuous still consists of 16 trays, 6 ft. in diameter; total height of still being 22 ft. The wash oil coolers are of the gray or open type, there being 8 banks, 30 pipes high and 20 ft. long.

There is one crude still 10 ft. in diameter, 16 ft. long which has a working capacity of 8,000 gallons. The column consists of the usual cast iron trays and dephlegmotor.

There is one pure benzol still, 10 ft. in diameter, 16 ft. long and working capacity of 8,000 gallons.

There is an agitator of 4,500 gallons (lead lined) driven by vertical steam engine.

The usual storage tanks for finished or salable products are installed over a concrete pit. A benzol loading station with overhead tanks for various products and steam driven loading pumps take care of the loading of salable products into tank cars or drums.

The usual Koppers acid regenerating plant for regenerating the sulphuric acid used in the agitator.

Normal coking time is 17 hours, gross.

The coal used is that from the company's Virginia City mines and a representative analysis is, as follows:

Moisture	2.21
Volatile Matter	24.60
Fixed Carbon	68.53
Ash	6.32
Sulphur	1.02

The coke produced from this is very high grade, being very firm, dense and of uniform structure and the tendency to cross fracture is very small. A typical coke analysis is, as follows:

Moisture	2.47
Volatile Matter	.90
Fixed Carbon	90.02
Ash	9.31
Sulphur	.92

Shatter Test—76 per cent above 2 in.—24 in. drop.

Surplus gas from this department is passed through mains to either the open hearth furnaces or rod mill reheating furnaces where it is used to good advantage.

For steam, there are two 400-hp. Casey-Hedges water tube boilers, gas fired or coal fired.

Blast Furnace Department:

This consists of one furnace stack, height 90 ft., bosh 19 ft. 6 in., hearth 14 ft. and top 13 ft. 6 in., equipped with McKee top and double skip. Bosh construction is of the water cooled type, 2 cinder notches and 12 tuyeres.

Cinder is handled from the furnace by hot pots to cinder dump and the slag is disposed of through a crushing plant for road work and railroads.

The hot metal is handled by ladles direct to the open hearth furnaces, although any surplus is put over a Heyl & Patterson single strand pig machine.

The stock house has a capacity of 10,000 tons of raw material. The coke is drawn from the stock house from bins directly over the skip and run over screens to eliminate the braize. This braize is blown into railroad cars by means of steam.

The furnace is filled by two larry cars equipped with scales.

There are four two-pass stoves 20 ft. x 90 ft. Four Southwark Vertical Blowing Engines, steam cylinders 42 in., stroke 60 in., air cylinders 84 in. x 60 in.

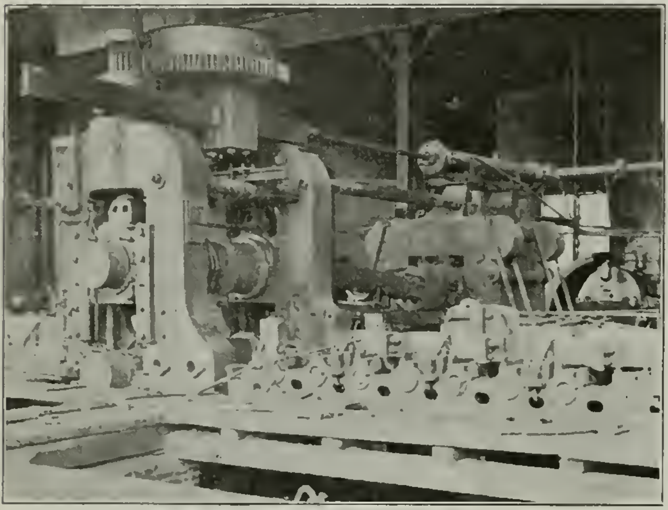


Fig. 2—View of blooming mill.

For steam there are eleven batteries of Stirling boilers, 375 hp each, gas or coal fired, equipped with automatic boiler feed together with boiler feed pumps, air compressors, etc.

There is a concrete reservoir, size 50 ft. x 246 ft. x 12 ft. equipped with three pumps, one of which is automatic. This is used as a reserve water supply for the furnace alone in case of trouble with main water supply.

Open Hearth Department.

The basic Open Hearth Department consists of six 75-ton (built for 50 tons) stationary furnaces designed and built by the Garrett-Cromwell Engineering Company, the hearths being 14 ft. x 30 ft. Each furnace is equipped with Blair water cooled ports and bulk heads, water cooled doors, door frames and roof channels.

The fuel used is producer gas from four Forter-Miller hand fired gas producers per furnace, there being 26 of these. The resulting gas averages 135 Btu per cu. ft. Two of the furnaces have Forter gas valves, the other four have valves of the mushroom type, designed and built by the company, which have given most satisfactory service. All valves are operated by hydraulic pressure.

The furnace stacks are 150 ft. high and 5 ft. inside diameter. The checker chambers are 21 ft. x 7 ft. x 16 ft. for gas and 21 ft. x 11 ft. x 16 ft. for air. No attempt is made to utilize waste heat under boilers.

Each furnace averages 15 heats per week of soft steel under .15 carbon. The charge consists of steel scrap and pig iron or hot metal in varying amounts from 30 to 70 per cent scrap according to market conditions. When using hot metal it is direct from the blast furnace for there is no mixer.

The stock loading yard has three 10-ton cranes; two Morgans and one Alliance.

In the pit are two ladle cranes, one 75-ton Morgan and one 100-ton Alliance and one 30-ton Morgan for handling slag pots. The pit equipment consists of 7 ladles of approximately 80 tons capacity and two Treadwell hot pots for slag.

Each of the two pouring platforms will accommodate 33 moulds. The size of the ingots are 18½ in. x 20½ in. and average 5,500 pounds in weight. All ingots are capped immediately after pouring.

There are two charging machines; one Wellman-Seaver-Morgan of 2½ tons capacity and one Alliance Machine Company of 3½ tons capacity. There is one 40-ton Morgan Engineering Company overhead electric crane on the floor for handling hot metal ladles (iron from blast furnace direct).

The material used for furnace bottoms is a calcined dolomite prepared at the plant, which has given excellent results. The rotary kiln in which this material is prepared is 120 ft. long and with diameter of 52 in., half of the length and 68 in. the other half. By-product gas is used as fuel. The kiln was manufactured by the Vulcan Iron Works.

The scrap used is railroad and agricultural bought in the local markets, generally in charging box size. In connection with this department there is maintained a scrap yard which prepares the scrap or rails for the furnaces.

There is a skull cracker structure for breaking pit steel and skulling the ladles approximately 60 ft. x 80 ft. In this skull cracker is one 15-ton Morgan electric overhead traveling crane equipped with E. C. & M. Company's magnet for handling drop ball, weighing 12,000 lbs. and a bucket for handling accumulated slag.

Blooming Mill Department.

The equipment consists of one 36 in. United Engineering & Foundry Company's two high mill. Rolls 36 in. in diameter: 10 ft. 8 in. long. Main spindle 9 ft.—vibration spindle 10 ft. 11 in. Pinion 36 in. x 8 ft. 9 in. staggard tooth. Operators are in pulpit in front of rolls. There are three operators and seven controllers. The screw down is hydraulically operated.

The roll table consists of a number of rolls 51½ in. x 12 in. diameter. The table is steam driven by Otis Elevator Company's double reversible engine, direct connected.

The 5 500 lb. ingot is reduced in nineteen passes to a 4 x 4 billet, 66 in., 260 pounds in weight for use in rod mill.

There are sixteen soaking pits, 6 ingot capacity, size of pits 8 ft. x 5½ ft. x 6½ ft. deep. The ingots are taken from the open hearth to stripper on mould cars pulled by dinkey engine. These cars are stripped in the blooming mill building by an electric stripper of 150 tons stripping capacity and 20 tons lifting capacity manufactured by the Alliance Machine Company. There is only one stripper used. In this same building there are two Morgan charging cranes, each 7½ tons capacity. The span for these three cranes is 62 ft. and length of runway 225 ft.

The ingots are heated with producer gas from eight Forter-Miller gas producers, which have reversing valves of the mushroom type. Producers are dry tops, 48 in. in diameter. The gases are taken off by four stacks 80 ft. high and 48 in. in diameter. No waste heat is utilized.

There is one mill table driven by a 38B, 50 hp, 220 volt D. C. Westinghouse motor controlled from rollers' pulpit by magnetic controller of E. C. & M. make. The balance of the roll tables are driven by three 25 hp 12A, 220 volt D. C. Westinghouse motors controlled from the shears. The drop table at the shears is controlled from this point and is driven by a 51D, 50 hp, 230 volt Westinghouse motor. There is one electric crane in the blooming mill building, a 30-ton Morgan, span 52 ft. and runway 260 ft. for handling rolls, etc. There is a covered crane runway 240 ft. long, 60 ft. span, on which is operated two electric overhead traveling cranes of 15 tons capacity (one Morgan and one Alliance) which are used for handling billets from this mill for sales purposes.

The mill is driven by one 48 in. x 60 in. Todd Twin reversing engine.

The shears are driven by a simple, vertical engine made by the United Engineering & Foundry Company.

While there are eight 375 hp Stirling water tube boilers, coal fired, they are not used; steam being furnished from the nearby rod mill boilers.

A typical 12-hour turn produces 600 gross tons.

Rod Mill Department.

The 4 x 4 billets from the blooming mill are conveyed by roll tables direct to the hydraulic pushers at the rod mill department. These billets are pushed into four reheating furnaces built by the Alex Laughlin Company, gravity discharge, 8 ft. 3 in. x 42 ft. long (inside dimensions). Two of these furnaces are fired by producer gas and the other two by by-product gas. The producer gas is regulated by cast steel valves and conveyed to the furnaces by underground flues. In these furnaces the billets rest on water cooled pipes. They are discharged on mill feed tables and conveyed to the continuous mill, of which there are seven stands 16 in.

The rod mill is of the Garrett type built by the Garrett-Cromwell Engineering Company. In addition to the continuous mill there are three stands 12 in. and eight stands 10 in.

The 16 in. mill is gear driven by one direct connected Allis tandem-compound 34 in. x 54 in. x 60 in. (No. 1 engine). The balance of the mill up to the finishing rolls is driven by Allis-Chalmers cross-compound, 48 in. x 84 in. x 60 in. (No. 2 engine) and the finishing rolls are driven by a Porter-Allen cross compound 28½ in. x 46 in. x 42 in. (No. 3 engine) located close to the finishing rolls. Nos. 1 and 2 engines being located in the power house on the opposite side of the mill. The shafts for the various rolls, other than the continuous mill, are rope driven.

There are seven reels, furnished by the Garrett-Cromwell Engineering Company, belt driven, controlled by friction clutch and manipulated by hydraulic power. The 260 lb. billet being rolled into No. 5 rods and coiled by these reels into a coil of approximately 25 in. inside diameter and 40 in. outside diameter. These coils drop on an apron link conveyor furnished by Garrett-Cromwell and are conveyed to rod buggies thence by tram track to the wire mill or rod yard.

Other equipment consists of one 15-ton Morgan electric overhead traveling crane close to the rod mill reheating furnaces, span 100 ft., runway 170 ft. This crane is used for picking the billets off the billet yard for the roll tables at such times as the blooming mill is not running.

Across the rod mill there is one 5-ton Morgan electric overhead traveling crane, span 91 ft., runway 336 ft., used for handling scrap from the rolls or changing rolls.

Serving this mill there are eight gas producers of the Duff type with dry tops.

The average production per turn is 300 tons.

Wire Mill Department.

The rods are delivered from the rod mill, a distance of approximately 300 ft., by buggies and tram track. Six bundles being loaded to each truck for the cleaning house. The necessary stem is inserted and rods handled by steam crane through cleaning house and onto ruster.

There are two bakers; one 10-track, brick flue, and one 7-track, steel pipe flue, of the Humphrey design. Coal fired.

The stocking from the bakers to the wire drawers is done by three Elwell-Parker tractors. These tractors also handle the weigh-up of the finished material.

Wire Department.

The Drawing Room is a steel frame, brick wall, composition roof, building (size 240 ft. x 360 ft.) containing six Humphrey wire drawing frames of 40 blocks each; four of which are driven direct by Crocker-Wheeler 230 volt D. C. motors of 300 hp each and the remaining two are driven by two 230 volt, 3 phase, induction motors, General Electric Company, of 400 hp each, with reduction gears.

Adjoining this is a fine wire drawing room (size 60 ft. x 100 ft.) containing two frames of 20 blocks each. On these blocks is produced wire from No. 15 to No. 20 gauge.

The bundles of rods weigh approximately 250 lbs. each. Chilled iron dies are used. The production of this department is approximately 30 per cent for nails and the balance sold as bright wire or is finished into other wire products.

Nail Department.

The finished wire is delivered to the Nail Department by Elwell-Parker tractors. In this department there are 153 Tiffin nail machines. These are operated from line shafts by four direct current motors. There being two rows of machines, the finished nails from both rows being delivered in the center and handled in ball bearing buggies to the rumblers. There are 12 of these of 15 keg capacity, each.

The necessary wooden kegs used in this department are furnished by a contractor who has a cooper shop inside of the plant inclosure.

From here the nails are delivered to two nail warehouses, size 60 ft. x 300 ft., each.

The size of the nail mill buildings are 60 ft. x 320 ft. and 60 ft. x 220 ft.

Galvanizing Department.

This department takes up approximately 50 per cent of the output of the drawing department. The wire is annealed through lead pans. The equipment consists of three, 36 wire, take-up frames made by Humphrey & Sons, Joilet, Ill. These frames are of the worm drive type, gears enclosed and running in oil. This equipment is operated by three Crocker-Wheeler variable speed motors, 50 hp, speed 300 to 900 rpm. There is a speed reduction here down to block of 15 to 45 rpm. The output of this department is divided between the Barb Wire Department and Woven Wire Fence Department or sold as galvanized smooth wire. Size of building 120 ft. x 300 ft.

Field Fence Department.

The equipment in this department consists of 13 square mesh fence machines of the Denning type making practically all styles and gauges of square mesh woven wire fencing. Size of building 60 ft. x 200 ft.

Barb Wire Department.

The Barb Department consists of 70 machines, which produce various styles and patterns of barb wire fencing.

The necessary barb wire spools are sawed from lumber nailed together in this department. Size of building 60 ft. x 240 ft.

Throughout these buildings there is a complete line of wire goods manufactured including cement coated nails, blued nails, staples, bale ties, straightened and cut wire, etc.

In addition to the nail warehouses already mentioned, there is a fence warehouse, 60 ft. x 480 ft., and a warehouse for barb wire, 60 ft. x 380 ft.

All buildings are of substantial character and floored with wood blocks. There being approximately 289,200 sq. ft. of floor space in the various wire departments.

The entire roof of the wire mill is divided into alternating high and low sections, each 20 feet wide and extending across the full width of the buildings.

Power.

The power equipment consists of 8 hand fired, coal burning, 375 hp Stirling water tube boilers; 6 stoker fired, coal burning, 375 hp Stirling water tube boilers; 8 stoker fired, coal burning, 500 hp Stirling water tube boilers. The stokers are of the type "E" made by the Combustion Engineering Company. Forced draft is maintained by two simple horizontal engines (Troy Engine Company) driving two Sirocco fans (American Blower Company). These boilers furnish power for the blooming mill, rod mill and power plant.

The rod mill is driven by three steam engines, as follows (previously mentioned):

No. 1—Allis Tandem Compound 34 in. x 54 in. x 60 in.

No. 2—Allis-Chalmers Cross Compound 48 in. x 84 in. x 60 in.

No. 3—Porter-Allen Cross Compound 28½ in. x 46 in. x 42 in.

The exhaust from these three engines operate two low pressure turbo-generators made by the Westinghouse Electric & Manufacturing Company. These are 2,000 kw, 2,300 volt, 3 phase, 3,600 rpm. These generators furnish all of the necessary power for the entire plant.

However, there is as a reserve, as follows:

In No. 2 Power House.

1—1,200 kw, 250 volt D. C., 84 rpm, Crocker-Wheeler Generators driven by one Allis-Chalmers cross compound 30 in. x 60 in. x 60 in. engine.

2—250 kw, 250 volt D. C., 200 rpm, Crocker-Wheeler engine sets driven by two Buckeye cross-compound engines 14 in. x 28 in. x 21 in.

Over this equipment there is an electric overhead traveling 10-ton Morgan crane, the span of which is 69 ft. and runway 357 ft.

In No. 1 Power House.

2—450 kw, 250 volt D. C., 135 rpm, Crocker-Wheeler engine sets driven by two Buckeye cross-compound engines 21 in. x 36 in. x 30 in.

2—150 kw, 250 volt D. C., 150 rpm, Westinghouse engine sets driven by Porter-Allen simple horizontal engines.

Bar Mill Department.

Located outside of the plant inclosure and within one-half mile of the plant is a merchant bar mill which includes a 20 in. mill and a 13 in. mill.

All sizes of merchant bars from 4 in. rounds to ½ in., 6 in. flats to ¾ in. in width and 4 in. squares to 7/16 in. are made on these mills, rolled from new billets.

General.

The water supply is from Will's Creek located approximately one-half mile from the plant, an all year stream of water, which is sufficient for the plant water supply and turbine cooling water.

All switching and tracks inside of the plant inclosure are owned and maintained by the company and there are six standard switch engines and three dinkeys for the necessary switching service.

For handling the necessary raw materials to and from stock piles there are five locomotive cranes of the following make:

1—25-ton Browning.
1—20-ton Industrial.
1—10-ton Industrial.
1— 6-ton Osgood.
2—10-ton Brown Machinery Company.

READY TO CONSTRUCT TUBE WORKS AT GARY

Construction is to be started at once on the proposed plant of the National Tube Company at Gary, Ind., according to Chairman E. H. Gary of the United States Steel Corporation. The plant, which will manufacture lap and butt weld tubes, will cost $15,000,000, according to estimates, and will have an annual capacity of 350,000 tons. This will add 20 to 25 per cent to the capacity of the Steel corporation's plant tube mills.

Announcement of the corporation's intention of building the works was made originally several years ago. The plant is to be financed by the use of $5,000,000 from the corporation's cash reserve and $10,000,000 in bonds, $7,000,000 of which are a 7 per cent issue of the Indiana Steel Company and $3,000,000 a 5 per cent issue of the National Tube Company. The bonds were underwritten by J. P. Morgan & Company and already have been subscribed.

Steel For Forge Welding

By FRANK N. SPELLER

In this paper the principal factors—method of manufacture, chemical composition, fluxing quality, susceptibility to heat and welding temperature—affecting the welding quality of steel are discussed and the average results of 80 tests made on forge welds of hammer-welded pipe are compared with the original material. In addition it is stated that tests have demonstrated that both steel not over 0.15 per cent carbon and minimum tensile strength of 47,000 lbs. per sq. in. and that not over 0.20 per cent carbon and minimum tensile strength of 52,000 lbs. per sq. in., are satisfactory for forge welding of pipe lines, penstocks, tank-car work and similar construction. In conclusion the writer believes that the most important consideration to produce uniformly good results in the forge welding of steel, is suitable material, well-trained operators and adequate facilities for the control of operations.

THE welding quality of steel, and the strength and reliability of such welds, depend on a number of factors, which include principally: methods of manufacture, composition, susceptibility to heat, fluxing quality, the mechanical appliances for handling and controlling the work, and the skill of the operator. There are so many factors present affecting the results that it is often difficult to determine which of these predominates in any particular case. This paper discusses particularly the characteristics of steel for forge welding, with brief reference to other factors which enter the problem.

Material and Workmanship.

Method of Manufacture. Wrought iron is most easily welded, probably on account of the presence of about one and one-half per cent of easily fusible cinder, which enables the metal to be welded at a comparatively low temperature and protects it from injurious oxidation at high temperature. For this reason wrought iron can usually be welded without much difficulty, but on account of the presence of this cinder internal defects such as laminations and blisters are more likely to occur after the metal has been brought up to the welding heat. What we term "soft welding steel" may be made by the Bessemer or open hearth process and should be made especially for this purpose, i. e., it should have, as far as possible, sufficient of the characteristics of wrought iron to readily form a "welding scale" at the lowest possible temperature. Very highly refined open hearth steels, "ingot iron" or electric steel, are, as a rule, lacking in this respect and so far have not shown as good welding quality as soft welding steel or wrought iron. Possibly these may be improved in this respect, but while these metals possess many advantages for other purposes, they do not at present appear to be well adapted for forge welding.

Composition. It is well known that comparatively small quantities of nickel, chromium and silicon interfere seriously with welding. Each of these should be under 0.05 per cent. Carbon has a lesser effect and should preferably be low, certainly under 0.30 per cent for any kind of forge welding. The higher the carbon, the lower the melting and burning point of the steel. By the burning point we mean the temperature at which the grain growth has increased to such a degree as to cause actual disintegration and intergranular oxidation of the metal. Sulphur under 0.05 per cent is not harmful and under certain conditions more may be present without injurious results. Phosphorus up to Bessemer limits is beneficial to welding.

Self-Fluxing Quality. On heating iron or steel above 1500 deg. F. an oxide scale is formed. The relation between the fusibility of the oxide scale to the temperature at which the metal "burns" is one of the most important factors determining suitability of the metal for welding. This scale consists usually of the magnetic oxide of iron (Fe_3O_4) with a certain percentage of "sonims"† from the iron (MnO, P_2O_5, SiO_2, etc.) which tend to make the scale more fusible. The method of manufacture and composition of steel have much to do with the formation of a suitable welding scale. The range of temperature between the melting point of the scale and the burning point of the metal is about 100 deg. F. in good welding steel and distinguishes this class of steel probably more than any other property. In fact, it is this self-fluxing quality which makes possible the commercial welding of iron and steel. Artificial fluxes, such as borax, may be used to lower the melting point of the scale in welding small parts of high carbon steel, but at present this is not practicable to apply satisfactorily when working on a large scale. The fusion of the scale also affords the operator a definite indication of the welding point, giving him close control over the operation.

Susceptibility of Metal to Heat. When normal wrought iron or steel is heated above the upper critical point (about 1570 deg. F. for soft steel) the grain grows at a rate depending on the temperature and time of heating. When a certain grain size is reached, a disintegration of the metal occurs with intergranular oxidation and the metal becomes "burnt." When this occurs, the metal is red-short and cold-short and useless for most purposes. The actual temperatures at which iron or steel is burned depends as much on the protective character and fusibility of the welding scale as anything else. High carbon steels are more susceptible to damage of this kind in welding than the same class of steel of lower carbon but the carbon is not the only factor, otherwise we might expect highly refined open hearth steel or "ingot iron" to weld as easily as charcoal iron.

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*For presentation at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York.

†Solid non-metallic impurities in steel, H. D. Hibbard, Trans. A. I. M. E., vol. xli, p. 803 (1910).

The large granular structure caused by exposure of the metal to welding temperature may be reduced to a fine structure (unless the metal has been excessively overheated) by a certain amount of mechanical forging applied while the metal is cooling or by reheating the metal to about 30 deg. F. above the upper critical point, followed by cooling in the air, which with soft steel may be comparatively rapid.

Welding Temperature. To produce intercrystalline union of two pieces of iron it is necessary that the clean surfaces be brought into close contact with a certain pressure. This is possible even at normal temperature with application of sufficient pressure in the case of soft steel, or may easily be done at a temperature slightly above the fusing point of the scale with comparatively little pressure, or at a lower temperature if the fusion point of the scale is lowered by the use of artificial fluxes, such as borax. So that the most favorable temperature for welding depends on the material and mechanical facilities. The usual temperature at which soft steel is found to weld satisfactorily ranges from 2500 to 2600 deg. F.

The skill and experience of the operator is, of course, a considerable factor in all welding. However, this is offset in forge welding to some extent by the facilities given him for controlling the heat and the work

Results of Tests.

A number of tests of forge welds (80 in all) made on two rings cut from the ends of hammer-welded pipe about ½ in. thick, compared with the original material taken from the same pipe, 90 deg. from the weld, gave results which are summarized as follows:

Material Away from Weld—Average transverse tensile test.	
Elastic limit, lb. per sq. in.	32150
Ultimate strength, lb. per sq. in.	52790
Elongation in 8 in., per cent	29.7
Reduction, per cent	58.6
Efficiency of Weld—Test pieces machined to uniform thickness.	
Average of all tests (80 tests), per cent	92.7
Average at extreme end (40 tests), per cent	90.3
Average 2 in. or more away from end (40 tests), per cent	95.0
Minimum at extreme end, per cent	69.0
Minimum 2 in. or more away from end, per cent	82.3

The above steel before welding ranged in tensile strength from about 47,000 to 62,000 lbs. per sq. in.—most of it being under 57,000 lbs. and under 0.16 per cent carbon.

Specifications.

This brings us to the question of specifications for steel best suited for forge welding. While skillful operators can undoubtedly make a good job of most steels when the carbon does not exceed that of flange quality, it seems desirable, everything considered, to limit the carbon to about 0.15 per cent for important parts where life and valuable property are at stake and a high efficiency of strength of weld is desired.

The present A.S.T.M. specification (A78-21-T) for forge-welding steel calls for steel of not over 0.18 per cent carbon having a minimum tensile strength of 50,000 lbs. per sq. in. A.S.T.M. Sub-Committee II of Committee A-1 now have under consideration substituting for this two grades of steel having the following chemical and physical properties:

	Grade A	*Grade B*
Chemical Composition		
Carbon, per cent*	not over 0.15	not over 0.20
Manganese, per cent	0.35 to 0.60	0.35 to 0.60
Phosphorus, per cent	0.04	0.04
Sulphur, per cent	0.05	0.05
Physical Tests		
Tensile strength, lb. per sq. in.	not under 47000	not under 52000
Yield point, lb. per sq. in.	not under 25000	0.5 tensile strength
Elongation in 8 in., per cent	not under 26	not under 24

*For plates over ¾ in. thick. 0.02 additional carbon is permissible.

Steel of both grades has been forge-welded and used in large quantities with an assumed weld efficiency of 90 per cent. The tests we have made indicate that this figure is warranted for pipe lines, penstocks, tank-car work and similar construction. A somewhat lower efficiency or higher factor of safety should, of course, be used for boilers and Class A unfired pressure vessels.

Boiler Code Requirements.

With respect to steel for forge welding, Part I, Section I, Par. 186 of the Boiler Code requires that:

> The ultimate strength of a joint which has been properly welded by the forging process shall be taken as 28,500 lbs. per sq. in., with steel plates having a range in tensile strength of 47,000 to 55,000 lbs. per sq. in. Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld.

Section III, paragraph L-29 reads:

> The ultimate strength of a joint which has been properly welded by the forging process shall be taken as 28,500 lbs. per sq. in., with steel plates having a range in tensile strength of 45,000 to 55,000 lbs, per sq. in. Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld.

The proposed section on unfired pressure vessels with reference to forge weldings, Pars. 5 and 8, reads:

> The ultimate strength of a joint which has been properly welded by the forge process shall be taken as 65 per cent of the tensile strength of the plate.

This weld efficiency seems rather low for Class A vessels and we believe that it should be still higher for Class B vessels.

In Pars. 2 and 3 of Sections I and III, firebox and flange steel are specified *for all parts* of the boiler. There seems to be a conflict in these specifications between the requirements for steel which may be forge welded, although apparently the intention is to use a steel of lower carbon for this purpose. This would seem to be in line with the best experience, but inasmuch as flange steel has apparently been successfully used for some time in forge welded boiler construction where part of the stress is carried by riveted straps, there would seem to be no reason for not continuing this practice when the weld is so reinforced.

Finishing.

After the weld is made, internal strains remain in the metal which should be released by annealing. This may be done by heating the piece uniformly to a red heat (about 1500 deg. F.) and allowing to cool in the air. Any objectionable amount of distortion which has occurred in the welding operation should be removed, preferably while the piece is at an annealing heat; otherwise it should be reformed and then annealed. Nothing has been said as to the method of welding, scarfing, preparation of the plate, or fuel to be used, as these vary considerably and good results have been obtained with widely different methods of working. Some operators prefer one form of scarfing, others none at all. Some use roller welding machines, but the majority use power hammers.* Good welding has been done with coke fire, producer gas, natural gas and water gas, the last being adapted for forge welding on a large scale.

To produce uniformly a high weld efficiency, the most important considerations are: suitable material, well trained operators, and adequate facilities for control of the work.

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*Details of mechanical appliances for hammer welding in modern American plants will be found in articles by E. F. Thum in *Chemical and Metallurgical Engineering*, September 21, 1921, October 19, 1921, and November 16, 1921.

Heat Losses From Steam Line Pipes

Losses from Bare and Covered Wrought-Iron Pipe at Temperatures Up to 800 Deg. F. Where High Temperature Superheated Steam Is Running—Investigations Made in the Mellon Institute.

By R. H. HEILMAN, Pittsburgh, Pa.

THE purpose of this paper is to report some of the data obtained recently on bare pipes operating at temperatures up to 800 deg. Fahr., and to present curves and formulas which will enable the engineer to solve readily the problems usually encountered in the calculation of heat losses from bare and covered pipes.

Bare-Pipe Heat Losses.

Manufacturers of pipe coverings often are required to guarantee that the application of a specified heat-insulating covering will effect a certain percentage saving of the heat which would be lost entirely from a bare pipe. Since the bare-pipe loss is the 100 per cent value against which the losses from the covered pipe must be compared, it is essential that the loss from the bare pipe shall be known accurately.

Many investigators have studied the heat losses from bare pipes. Perhaps the most noteworthy of these experimentalists was the French physicist Péclet. Paulding, in his book on Steam in Covered and Bare Pipes, has worked out the theory of heat losses from bare pipes in the light of the researches of Péclet. However, the findings of later investigators do not support the results given by Paulding. Owing to the fact that Péclet's experiments were conducted at very low temperatures, while subsequent investigators confined themselves mostly to one pipe size only, the Mellon Institute deemed it advisable to carry on the research to higher temperatures and to pipes of various sizes. By testing pipes of various sizes under the same condition, it was thought that more reliable data could be secured than by comparing the results of other investigators on pipes of various sizes under different conditions. Accordingly, tests were made on 1-in., 3-in., and 10-in. pipe.

The method of testing was practically the same as that described by G. D. Bagley in his paper on Conversion of Heat Losses from Pipes and Boilers, presented before the Society in 1918, except that the pipe-covering tester had been improved. A Leeds & Northrup type K potentiometer was substituted for the millivoltmeter, and a General Electric saturated-core-type voltage regulator and smaller thermocouples were added. Fig. 1 shows a view of the laboratory and the testing apparatus.

When conducting tests on bare pipes it is very desirable that the room temperature remain constant throughout the work, for the rate of heat loss is dependent upon the absolute temperature as well as upon the temperature difference. The 1-in. pipe was selected for test at the higher temperatures, as the relatively small amount of heat loss from a 1-in. pipe could not greatly affect the room temperature.

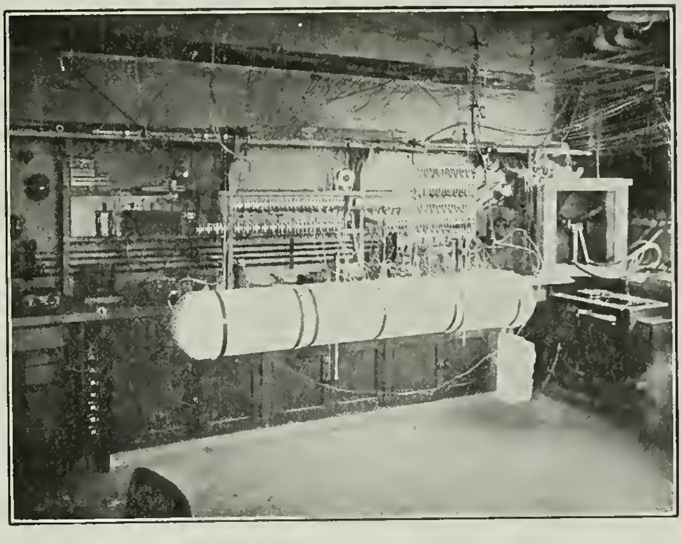

Fig. 1—Laboratory and Testing Apparatus.

This pipe was run up to a temperature of 800 deg. Fahr. The average room temperature throughout this test was 81 deg. Fahr. and the temperature did not vary more than 1.8 deg. Fahr. during its progress.

When the emissivity coefficient is plotted against the heat loss, it is found that the curve obtained is not a straight line, but falls off at the higher temperatures. This means that the heat loss from a bare pipe does

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not increase as rapidly at the higher temperatures as would be anticipated. A possible explanation for this condition is that the convection loss at the higher temperatures does not increase as rapidly as at the lower temperatures.

The first test on the 1-in. pipe was checked by a second test on another 1-in. pipe and both tests corresponded exactly at the higher temperatures.

The location of the curves for the 3-in. and the 10-in. pipes was obtained by experiment at the lower temperatures, as indicated by the solid lines in Fig. 2. The values for the higher temperatures are the result of extending the curves parallel to the curve obtained for the 1-in. pipe. This procedure was necessary because of the fact that the larger pipes could not be raised to the higher temperatures without raising considerably the temperature of the room. Tests are now in progress to ascertain the loss from vertical iron pipes, and the results will be reported later.

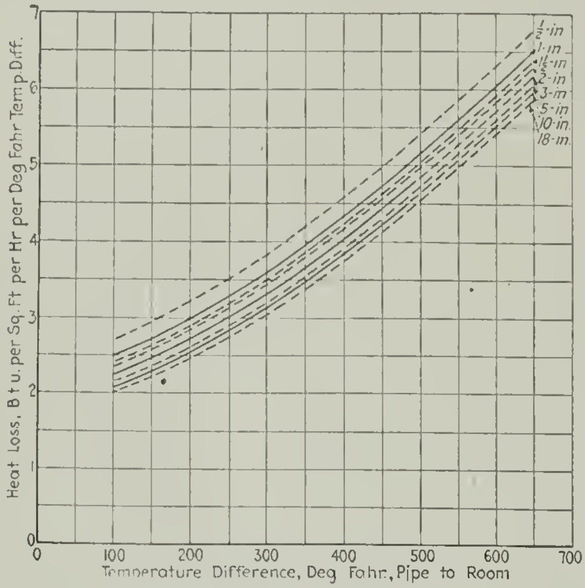

Fig. 2—Bare-Pipe Loss Curves.

In Table 1 the loss in dollars and cents and in pounds of coal per 100 lineal feet of horizontal bare iron pipe is tabulated for temperatures up to 664 deg. Fahr. The loss varies from $1.32 for 100 lineal feet of ½-in. pipe at 180 deg. Fahr. to $297.50 for 100 lineal feet of 18-in. pipe at 664 deg. Fahr.

Theory of Heat Loss From Insulated Pipes.

In order to calculate the loss of heat from an insulated pipe or boiler, it is necessary to know the total temperature drop from the pipe to the surrounding air; and to enable one to make accurate calculations it is required that the component temperature drops be known.

The total temperature drop from the steam inside a pipe to the outer air can be considered as made up of four components, as follows:

(a) Drop from steam to the outer surface of the pipe.

(d) Drop from outside surface of the pipe to inside surface of the insulation.

(c) Drop from the inside surface of the insulation to the outside surface of the insulation.

(d) Drop from outside surface of the insulation to the surrounding air.

The temperature drop from the steam to the outer surface of the pipe depends upon the resistance to heat flow offered by the film at the inner surface and the resistance offered by the iron wall of the pipe.

This combined resistance is very low, owing to the high conductivity of the iron and the relatively high conductivity of the water film. Consequently the temperature drop is very low. No attempt has been made to measure the above temperature drop in this investigation, as it was considered to be so small as to be negligible. This drop has been measured for saturated steam by L. B. McMillan* and found to be a fraction of a degree. However, a test conducted by Eberle† for superheated steam shows a drop as high as 10 deg. Fahr. This drop should be taken account of when making calculations for superheated steam.

The temperature drop from the outside surface of pipe to the inner surface of the insulation depends upon the resistance to heat flow offered by the air space between the surface of the pipe and the inner surface of the insulation. The heat flow which takes place in this case is due to radiation, conduction, and convection. Since the radiation increases as the fourth power of the absolute temperature difference, it is to be expected that the temperature drop would tend to decrease at the higher temperatures.

The temperature drop from the outer surface of the pipe to the inner surface of the covering for 1-in., 3-in., and 10-in. pipe is shown in Fig. 3. These curves show that the temperature drop increases as the pipe diameter decreases. A test was also made on a 3-in. pipe with an air space of 1.2-in. between the surface of the pipe and the insulation. By comparing this curve with the curve for an air space of 0.1 in., it is observed that the temperature drop for a 1.2-in. air space is only a few degrees more than for an air space of 0.1 in. This is probably due to the fact that for air spaces much greater than 0.2 in. convection currents are increased, thus causing an increase in heat loss.

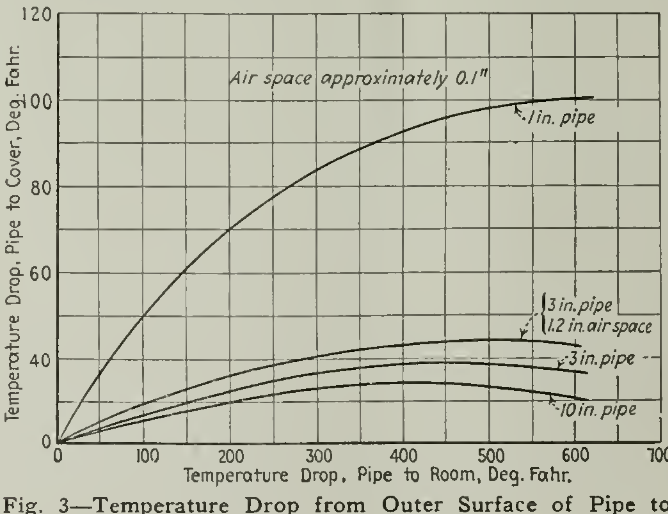

Fig. 3—Temperature Drop from Outer Surface of Pipe to Inner Surface of Covering.

Since the flow of the heat is directly proportional to the cross-sectional area, and inversely proportional to the length of the path, it is obvious that the presence of a 1.2-in. air space between the surface of the 3-in. pipe and the inner surface of the insulation will cause an increase in the total amount of heat lost from the surface of the pipe, provided, of course, the air space is not as good an insulator as the covering itself. In this case the insulating value of commercial coverings is many times greater than the insulating value of the air space.

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*Trans. Am. Soc. M. E., vol. 37, p. 928.

†Mitt. uber Forschungs-Arbeiten auf dem Geb. des Ing., helf 78.

The results of this test show that an air space of over 0.25 in. is of little use as an insulator on flat surfaces at high temperatures, and that this air space is of little value as a protection to the covering from the effects of the high temperatures. This test also demonstrates that coverings should be kept as close as possible to cylindrical surfaces, because the insertion of an air space of approximately 0.1 in. between the pipe and insulation actually increases the overall loss. An examination of Fig. 3 shows that the temperature drop for a 0.1-in. air space is approximately equal to that for 0.1 in. of commercial insulations, so that this temperature drop can be neglected in calculations and the pipe covering considered as fitting close to the pipe with the pipe temperature and the temperature at the outer surface of the covering as the temperatures bounding the covering.

TABLE 1—LOSSES FROM HORIZONTAL BARE-IRON STEAM PIPES[1]

From 100 Lineal Feet of Pipe per Month of 30 Days with Steam in Pipes 24 Hr. per Day. Coal at $4.00 per Ton of 2,000 Lb.

GAGE PRESS.	HOT WATER			10 LBS.			80 LBS.			120 LBS.			160 LBS.			200 LBS.			200 LBS. AND 100° F. SUPERHEAT.			275 LBS. AND 250° F. SUPERHEAT.		
TEMP.	180° F			239.4° F.			324.0° F.			350.0° F.			370.7° F.			387.9° F.			487.9° F			664.3° F		
PIPE SIZE	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.	DOLLARS LOSS	POUNDS COAL	B.T.U. PER LINEAL FT. PER °F. DIFF. PER HR.
½"	1.32	526	.605	2.24	897	.670	3.92	1566	.779	4.51	1805	.815	5.25	2010	.846	5.53	2210	.875	8.60	3440	1.040	16.15	6460	1.375
1"	1.91	763	.878	3.26	1305	.973	5.72	2290	1.138	6.25	2601	1.178	7.27	2910	1.242	8.07	3230	1.280	12.56	5026	1.520	30.55	12220	2.600
1½"	2.65	1060	1.220	4.54	1818	1.357	7.98	3190	1.586	9.28	3710	1.676	10.42	4165	1.751	11.36	4550	1.804	17.94	7175	2.170	34.30	13720	2.920
2"	3.24	1297	1.491	5.36	2142	1.600	9.78	3910	1.943	11.37	4549	2.052	12.75	5100	2.145	14.00	5600	2.220	22.10	8825	2.670	42.20	16890	3.590
2½"	3.86	1545	1.778	6.65	2660	1.984	11.66	4660	2.320	13.66	5460	2.464	15.25	6100	2.564	16.70	6690	2.650	26.64	10650	3.220	50.50	20200	4.300
3"	4.56	1824	2.100	8.24	3292	2.460	13.88	5550	2.760	16.14	6450	2.910	18.04	7210	3.030	19.84	7945	3.150	31.60	12640	3.820	58.25	24300	5.170
3½"	5.18	2070	2.380	8.89	3554	2.655	15.82	6325	3.145	18.31	7322	3.305	20.50	8200	3.450	22.60	9040	3.580	35.90	14360	4.345	69.00	27600	5.860
4"	5.78	2305	2.650	9.87	3950	2.950	17.70	7075	3.520	25.50	8200	3.700	22.85	9145	3.842	25.15	10060	3.981	40.10	16040	4.850	72.40	30920	6.580
4½"	6.35	2540	2.920	10.94	4370	3.260	19.48	7790	3.878	22.60	9025	4.075	25.30	10120	4.250	27.75	11100	4.400	44.05	17620	5.326	85.60	34240	7.286
5"	6.95	2780	3.200	11.97	4790	3.575	21.25	8500	4.232	24.62	9850	4.450	27.60	11050	4.650	30.40	12140	4.805	49.35	19740	5.960	94.50	37800	8.050
6"	8.20	3280	3.775	14.21	5680	4.240	25.30	10110	5.024	29.30	11720	5.295	32.80	13120	5.522	36.00	14420	5.715	57.50	23000	6.955	112.50	45000	9.580
7"	9.40	3760	4.325	16.18	6470	4.826	29.10	11640	5.782	33.70	13480	6.090	37.60	15040	6.324	41.60	16650	6.560	66.25	26500	8.010	129.00	51550	10.97
8"	11.00	4398	5.050	18.25	7300	5.450	32.60	13030	6.455	37.65	15050	6.840	42.40	16940	7.125	46.05	18420	7.300	74.75	29900	9.050	146.20	58500	12.44
9"	11.62	4650	5.350	20.35	8130	6.070	36.25	14500	7.210	42.10	16840	7.600	47.22	18900	7.950	51.98	20790	8.230	83.50	33400	10.10	162.60	65050	13.84
10"	12.68	5065	5.925	22.05	8820	6.584	40.20	16100	8.010	46.70	18690	8.440	52.30	20910	8.805	57.75	23100	9.150	97.50	39000	11.18	180.00	72000	15.30
12"	15.00	6000	6.995	26.44	10580	7.890	47.40	18950	9.425	55.40	22120	10.00	61.76	24700	10.40	70.00	28010	11.14	109.30	43700	13.22	213.50	85500	18.18
14"	16.60	6635	7.625	28.90	11560	8.620	52.00	20800	10.34	60.50	24200	10.92	67.50	27000	11.36	74.10	29650	11.76	119.40	47740	14.43	233.00	93300	19.85
16"	18.82	7525	8.650	32.80	13120	9.790	58.76	23500	11.70	68.40	27320	12.34	76.10	30410	12.80	84.25	33700	13.35	135.00	54000	16.34	265.00	106000	22.55
18"	21.00	8400	9.650	36.10	14460	10.80	65.40	26150	13.00	76.50	30570	13.80	85.50	34200	14.38	93.75	37500	14.87	151.20	60500	18.30	297.50	119000	25.30

The temperature drop from the inside surface of the insulation to the outside surface of the insulation depends upon the resistance to heat flow offered by the insulation itself. Heat is transmitted through the insulation by means of radiation, conduction and convection. The relative amount of each of these three factors depends entirely upon the construction of the insulating material.

The amount of heat transmitted through the insulation and the temperature drop from the inner to the outer surfaces determine what is generally called the absolute conductivity of the insulation. However, this does not give the true absolute conductivity of the insulation, but gives what may be called the mean absolute conductivity. The true absolute conductivity for an insulating material, say, 1 in. in thickness can be represented by a curve. The absolute conductivity for a given material increases as the temperature increases, and therefore the absolute-conductivity curve depends upon the thickness of the covering and also upon the curvature of the covering.

The drop in temperature, or the temperature-gradient curve through the insulation, then depends upon the thickness of the covering and the curvature. In a cylindrical covering the resistance to heat flow diminishes as the outer surface is approached, the temperature drop becomes less, and the gradient curve is bowed downward if the curvature alone is taken into consideration. However, the absolute conductivity decreases as the outer surface is neared, with a consequent bowing up of the gradient curve, and the two tend to counteract each other, so that the temperature-gradient curve may be bowed either up or down or be a straight line, depending upon the curvature of the cylinder. The temperature-gradient curve for a flat surface should bow up.

It is highly desirable that tests should be conducted on commercial steam-pipe coverings of different thicknesses and at different temperatures, in order to obtain mean absolute-conductivity curves for the different thickness.

The temperature drop from the outer surface of the insulation to the surrounding air depends upon the amount of heat emitted by radiation and air contact.

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[1] In this table coal has been figured at $4.00 per ton of 2,000 lb., 13,000 Btu per lb. of coal; labor, boiler-room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70 per cent; air temp. 70 deg. Fahr. Experimental data obtained at the Mellon Institute.

This in turn is dependent upon the nature of the surface of the body, the shape of the body, the excess of its temperature over that of objects to which radiation takes place, and the absolute value of the temperature of these bodies. Commercial steam-pipe coverings are invariably covered with a canvas jacket. From the above-mentioned facts it is obvious that the loss from a canvas surface at a given temperature is independent of what is under the canvas, so that, if the canvas-loss law can be ascertained, this law may be applied to the loss from steam-pipe coverings and thus the temperature of the outer surface of the insulation can be determined. In making calculations of heat loss through an insulation, it is absolutely necessary to know the temperatures at the inner and outer surfaces.

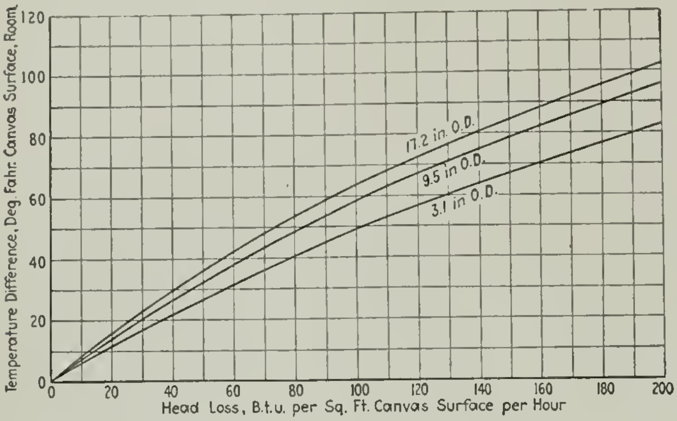

Fig. 4—Canvas-Surface Loss-Curves.

Péclet made a careful study of the heat emissivity from various surfaces, canvas surfaces included. As mentioned, however, his experiments were conducted at relatively low temperatures. McMillan made a study of the heat emissivity from a canvas surface in his study of commercial steam-pipe coverings, but he confined his experiments to one pipe size only. Nevertheless, McMillan's results in the form of a curve present a readier means of calculating the losses from steam-pipe coverings than do Péclet's, whose observations, while taking all the variables into consideration, are in too complicated a form to provide a ready means of calculation.

Since McMillan's canvas-surface-loss curve was obtained from experiments on one pipe size only, this curve can be used in making calculations on coverings of a diameter approximately the diameter of the coverings tested. In order to be able to calculate the loss of heat from pipe coverings of any diameter, it has been necessary to obtain the canvas-surface-loss curves for various diameters. Accordingly, coverings were tested on the 1-in., 3-in., and 10-in. pipes used in determining the bare-pipe losses. The average outer diameters of the coverings used were 3.1 in., 9.5 in. and 17.2 in. The results of these tests are shown in Fig. 4.

In order to simplify the calculations necessary to determine the loss of heat through coverings of various diameters, the equations of the three curves shown in Fig. 4 have been derived. In these equations—

T_d = temperature difference between canvas surface and room, deg. Fahr.

h = total Btu loss per hour per square foot of canvas surface.

D = outer surface diameter, inches.

$$\text{3.1 in. diameter:}\quad T_d = \frac{272.5\,h}{h + 456.5} \quad \ldots\ldots [1]$$

$$\text{9.5 in. diameter:}\quad T_d = \frac{272.5\,h}{h + 368} \quad \ldots\ldots [2]$$

$$\text{17.2 in. diameter:}\quad T_d = \frac{272.5\,h}{h + 328.4} \quad \ldots\ldots [3]$$

These equations can be combined to give the general equation:

$$T_d = \frac{272.5\,h}{h + \dfrac{564}{D^{0.19}}} \quad \ldots\ldots\ldots\ldots [4]$$

which is approximately accurate for diameters up to 2 ft.

It is believed that these curves are fairly accurate, inasmuch as they were obtained from the results of numerous tests on different materials.

Thermocouples were used in determining the canvas temperatures. During this investigation, it was found that the couple, when just inserted under the canvas, would invariably read low. This difficulty was overcome by inserting it under the canvas for a distance of several inches, this distance depending upon the size of the couple and the temperature of the covering. From a theoretical consideration of the question, it can be shown that the minimum distance to which the thermocouple can be placed under the canvas is reached when the temperature of the thermocouple wires, a short distance from the junction, is the same as the temperature at the junction. When this condition is reached, there is no flow of heat from the junction to the wires and consequently no lowering of the junction temperature.

Sample Calculations.

A covering 2 in. thick, having a mean absolute-conductivity coefficient of 0.56, is placed on a 4½-in. outside-diameter pipe maintained at a temperature of 400 deg. Fahr. The temperature of the surrounding air is 70 deg. Fahr. Determine the heat flow in Btu per hour per sq. ft. of pipe surface.

The heat flow through a cylinder is given by the equation:

$$H = \frac{K\,(T_1 - T_2)}{r_1 \log_e \dfrac{r_2}{r_1}} \quad \ldots\ldots\ldots\ldots [5]$$

where T_2 is the temperature at the outer surface of the covering. To obtain T_2, knowing only T_1, the pipe temperature and T_3, the room temperature, it is necessary to change the form of the equation so as to include T_d. The equation for T_d, as developed from experimental results, is

$$T_d = \frac{272.5\,h}{h + \dfrac{564}{D^{0.19}}} \quad \ldots\ldots\ldots\ldots [4]$$

whence

$$h = \frac{K\,(T_1 - T_3 - T_d)}{r_2 \log_e \dfrac{\;}{r_1}} \quad \ldots\ldots [6]$$

in which

h = Btu loss per hour per sq. ft. of canvas surface.
K = mean absolute conductivity of insulation.
r_1 = radius of inner surface of insulation, inches.
r_2 = radius of outer surface of insulation, in inches.
T_d = temperature difference between outer surface of insulation and room, deg. Fahr.

Substituting in [6], there results

$$h = 0.56 \left[\frac{400 - 70 - \dfrac{272.5\,h}{h + \dfrac{564}{8.5^{0.19}}}}{4.25 \log_e \dfrac{4.25}{2.25}} \right]$$

$$= 0.207 \left(330 - \frac{272.5\,h}{h + 375}\right)$$

$$= \frac{-363.1 \mp \sqrt{363.1^2 + 4 \times 25{,}600}}{2} = 60.4$$

$$H = 60.4 \times \frac{4.25}{2.25} = 114 \text{ Btu loss per hr. per sq. ft.}$$

of pipe surface.

The temperature at the outer surface of the covering can be obtained by substituting the value of h in the equation $T_d = \frac{272.5\,h}{h + 375}$, reducing to $T_d = 37.6$. Therefore the temperature of the outer surface of the covering is

$$37.6 + 70 = 107.6 \text{ deg. Fahr.}$$

Material-Handling Equipment as Used in the Iron and Steel Industry

A Description of the Handling Machinery Used in the Manufacture of Steel from the Time the Ore Leaves the Mines Until the Steel Goes Through the Last Process at the Mill.

By **F. L. LEACH**, New York, N. Y.

THE iron and steel industry probably requires a greater diversity of material-handling equipment than any other type of manufacturing, because of the enormous bulk and weight to be handled. From the time the material leaves the mines until it is turned out of the mills as finished product it is constantly being moved by heavy conveying machinery of all descriptions. It is the intention of the author to describe this equipment with the idea of bringing out weak points in present day practice, and possibly open the way to strengthen the weakest links in conveying methods used.

2. As the principal object of this paper is to describe the machinery used about the industrial plant, just a brief description will be given of the handling methods before the material reaches the plant.

3. The ore is mined and conveyed to convenient lake ports by means of special gondola cars. The latest type of these cars is designed to carry 120,000 lbs. The total weight of car is 33,500 lbs., therefore the ratio of revenue load to total weight is 78.1 per cent. A good example of a modern port is the Duluth, Missabe & Northern Railway docks at Duluth, Minn., the No. 5 dock of which has the greatest storage capacity of any on the Great Lakes. It is 2,304 ft. long, has 384 pockets, and a storage capacity of 134,400 tons.

4. At the present time ore handling on the Great Lakes is carried on by a fleet of vessels unequalled anywhere in the world. Some of these vessels are capable of handling a cargo of 15,000 tons, and are over 600 ft. long. During the year 1916, 66,658,466 tons of ore were carried by the vessels from the upper Great Lakes to southeastern ports. The steamer *Homer D. Williams* carried 462,490 tons during the season of 1920.

5. Vessels equipped for self-unloading have been developed for handling stone and ore. The hold in such cases is divided into bins, which deliver the material by gravity to a belt coneyor running lengthwise of the vessel; this conveyor delivers the material to an elevator which hoists it to another belt conveyor suspended in a horizontal position from the masts of the vessel and capable of being moved radially and vertically like the boom of a derrick. This belt conveyor delivers to the storage pile on the dock, and it is possible to distribute the material onto the dock at any point or height desired within the scope of the boom conveyor.

6. Ore-unloading equipment has probably been developed to the highest point of efficiency at the ports on the Great Lakes. An example of this is Ashtabula Harbor on Lake Erie, where there are eight Hulett ore unloaders having a capacity of 15 tons each. They have a record of unloading seven boats of a total capacity of 77,000 tons in 22 hours actual time. Four 17-ton capacity machines of this type have unloaded a cargo of 13,000 tons in 3 hours and 25 minutes.

7. These unloading machines remove the ore from the boat and dump it directly into railroad cars for shipment to inland plants, or they place it in a bin located at the rear of the machine where it may be picked up by a traveling ore bridge and placed in storage piles.

.8 Railroad cars have been developed for handling ore up to 120 tons capacity. Ore shipped to inland plants in bottom-dumping cars may be unloaded directly into

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*For presentation at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers, 29 West Thirty-ninth Street, New York.

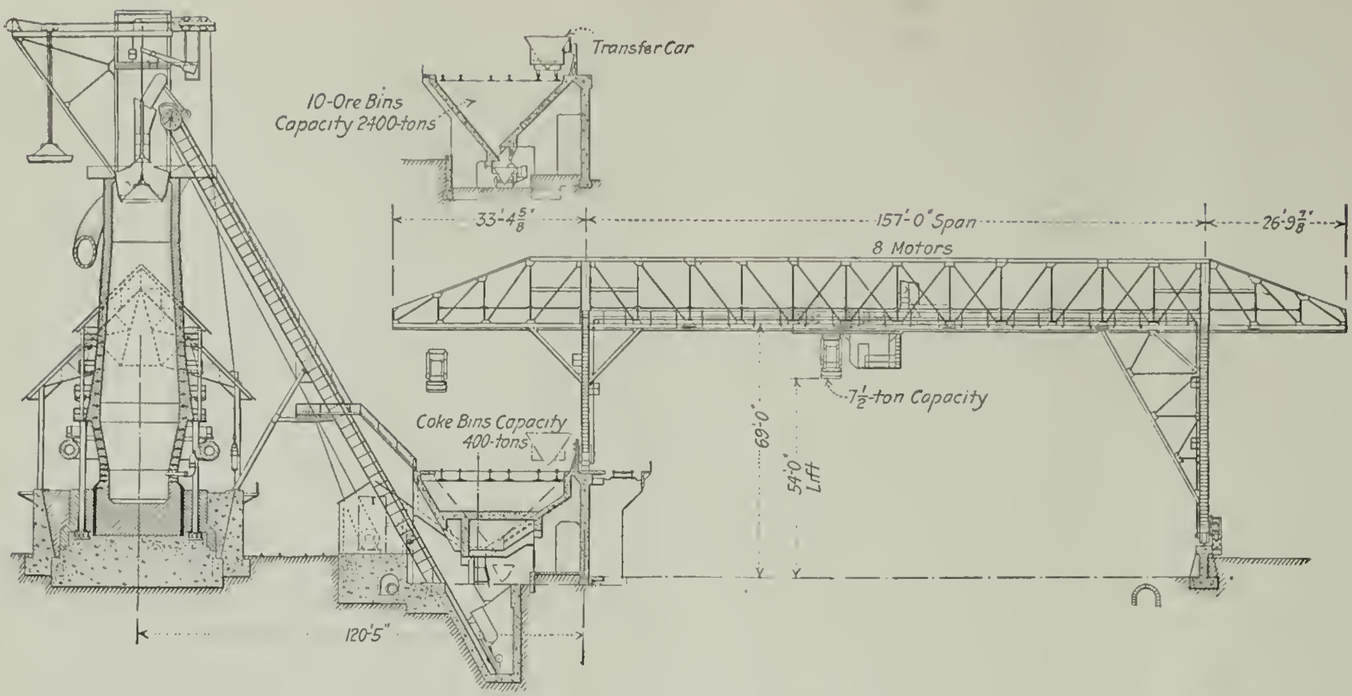

Fig. 1—Section through blast furnace and ore yard showing relations of ore bridge, bins and furnace.

bins by gravity. However, the modern method is to use a traveling rotary car dumper, which can be spotted at any point in the length of the ore yard. The cars of ore are placed one at a time on the dumper, turned upside down and the ore dumped into a concrete pocket that extends the full length of the ore yard. An ore bridge, similar to the one shown in Fig. 1, distributes the ore to the storage pile in the yard. Rotary car dumpers have been developed so that three men can unload about 20 cars per hour.

9. Cars of 240,000 lb. capacity have been designed with a total dead weight of 78,800 lbs., giving a ratio of revenue load to total weight of 75.4 per cent.

10. The traveling ore bridge is another valuable link in material-handling equipment and is used in many different ways in handling the ore at unloading docks. Some machines are designed for the purpose of removing the ore directly from the boats, in which case it may be placed in its proper location in the ore yard without rehandling. But in the case mentioned above, the bridge is used for distributing ore in the yard after the unloaders have removed it from the boat. This is the most economical method where large quantities are to be handled.

11. One of the largest bridges of this type ever built is 612 ft. long overall, and is used at the Western Pennsylvania Dock Company at Cleveland, Ohio. This bridge handles a 15-ton bucket and covers an ore storage of over a million tons.

12. Fig. 1 shows how these bridges may also be used to place the ore and limestone in bins, preparatory to sending them to the blast furnace. Several different types of bins are used, although the principle is the same in each. The ore is placed in the bin either by the ore bridge, or by gondola-type hopper cars and it passes down through the bin by gravity as required, through a shut-off gate into a lorry car. The types of bins ordinarily used are the overhead design shown in Fig. 1 and the tunnel type in which the lorry car goes through a tunnel beneath the bridge.

13. The choice of these two types is decided by the topography of the land on which a plant is built and by climatic conditions. From the bins an electrically driven weighing lorry car is used to convey ore, limestone and coke to the blast furnace skip hoist.

14. Fig. 1 shows how material is conveyed from the stock yard and bins to the top of the blast furnace, dumped into the bell hopper by the skip car, and finally deposited inside by the well known double bell system. Two of the products of the blast furnace are pig iron and slag, which are drawn off at the base in a molten state. Both iron and slag were formerly allowed to run from the furnace into sand molds and handled after cooling. Most plants today, however, run the molten iron and slag directly into ladles supported on special cars. In this way the iron is transported either to a pig-casting machine where it is cast into pigs, or to a mixer at the open hearth plant, where it is kept in the molten state, or further refined before it is placed in the Bessemer converter, for the duplex process. The molten pig iron may also be conveyed direct to the open hearth furnace for the straight open hearth process.

15. The slag is disposed of in various ways, since it has become of considerable commercial value in the last few years. After having been allowed to cool it is crushed to various sizes, and then used in the place of crushed stone.

16. The Croxton method is one way of handling slag. By this method it is dumped into concrete pits across the bottom of which heavy chains have been laid at intervals of about five feet. When the pit has been filled with slag to a depth of about 18 in. to 24 in. the chains are pulled up through the slag by an overhead crane. This breaks up the slag so that it may be conveyed by means of the crane and grab bucket to a crusher at the end of the slag pit.

17. Another method is to dump the molten slag into a pit partly filled with water, thereby granulating it so that it may be removed by the crane and a grab bucket. This granulated slag makes a very good railroad ballast.

(To be continued)

Eastern Company Rebuilds Blast Furnace

The Thomas Iron Company at Hokendauqua, Pa., Have Completed the Reconstruction of Their No. 3 Blast Furnace. Additional Power Facilities and a Pig Casting Machine Also Installed.

By RICHARD PETERS, JR.
Manager of Sales, Pulaski Iron Company

THERE hangs on the walls of the office of The Thomas Iron Company in Easton, Pa., a frame enclosing a document which is unique in the annals of the iron trade, in that it records the inception of the only American company which has continued to manufacture pig iron exclusively for nearly 70 years without reorganization or without having a change in its corporate name. This interesting relic is the original autographical list of the 26 subscribers to the stock of the company, showing the names, addresses and amounts taken by each, and attests to the incorporation of The Thomas Iron Company on April 4, 1854.

The project was started, however, nearly two months earlier than this date, as the result of a meeting of prominent men of the Lehigh Valley, interested in the development of the anthracite iron industry, just then getting under headway. A resolution adopted at the original meeting named the company in honor of David Thomas, who conceived the new undertaking and who had been the pioneer in the successful manufacture of anthracite iron on a commercial scale. The original capitalization of $200,000 represented a considerable outlay for those days, as it took courage to invest largely in a venture so new as that of smelting iron with a fuel of which many iron masters were skeptical.

Even before the state had granted the charter of incorporation, a site for the erection of works had been purchased, on the west bank of the Lehigh river, a short distance north of the Lehigh Crane Company's plant at Catasauqua. The farm land acquired on which to build the furnaces and town site was named "Hokendauqua," the derivation being from the language of the Delaware Indians and meaning "Land Seeking." Arrangements were made to promptly start the erection of two blast furnaces, to be known as numbers one and two, and contracts were placed for the necessary engines, boilers and other iron work. The stacks were built of masonry, following the practice of those days, and they had extensions to the tunnel heads like Turkish minarets. When the plant was completed and put in blast in 1855, it was the subject of much favorable comment, so much so that Percy in his 'Metallurgy," published in London in 1864, states that the Thomas works "stand pre-eminent" as illustrative of American manufacture by reason of its "beauty, size and convenience of build, and for its historic interest." Detailed drawings and descriptions as well as records of the furnaces are incorporated in the work of Percy. Prior to this, in 1859, Prof. Lesley, the Secretary of the American Iron Association, described the Thomas furnaces in the following language: "Built together and alike, 18 feet across the bosh and 60 feet high, and blown by two blast cylinders in common, at the extraordinary pressure of 8½ pounds to the square inch, these twin stacks have steadily kept in advance of all the other furnaces of the United States. In 1856 they made 17,446 tons together. In a word here stands the demonstration that a large and well built crucible, properly stocked with good ores and properly blown with power to spare, must be a great and continual success."

The supplies of raw materials were conveniently located at Hokendauqua, especially the brown hematite ores, which abounded in the neighboring counties. Access to these ores, however, was by teaming only, at a considerable expense, so that two years later we find the Thomas Company joining the Crane works in building a railroad to the ore district. The road was named the "Catasauqua & Fogelville," and while now controlled by the Reading System, yet The Thomas Iron Company still retains its original interest in the company. In 1882, the Ironton Railroad was purchased so that control could be had of the ore and limestone reached by its line, but at the present time this road is more important as a cement carrier, due to the developments of this industry in the region.

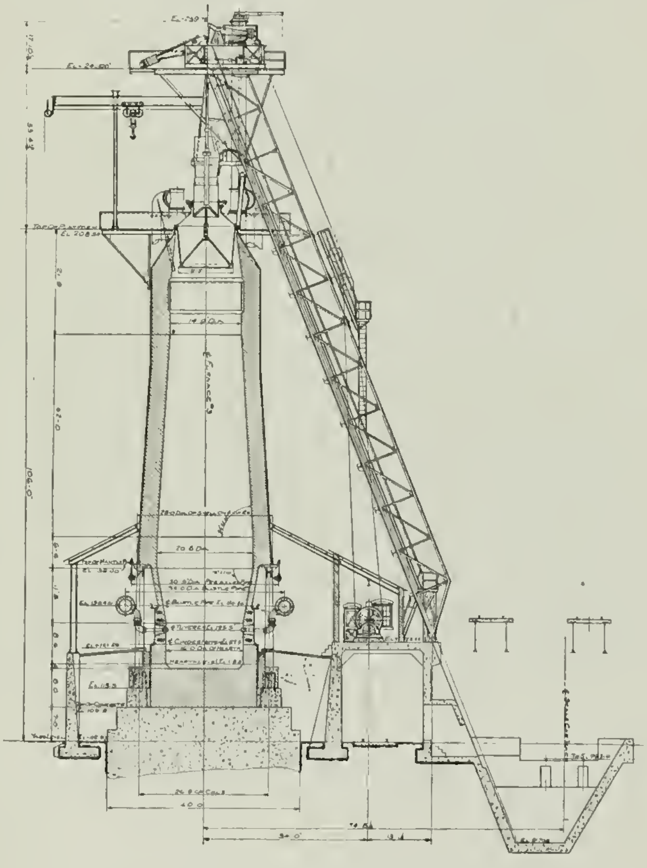

Fig. 1—Cross section of furnace.

The needs of the country for pig iron during the Civil War prompted the erection in 1862 and 1863 of two additional stacks of the same general construction as the original ones. In 1868 the plant of the Lock Ridge Iron Company at Alburtis was acquired, and an additional furnace was erected at that place the following year. With its increased production, the Thomas company had already taken a foremost place among American iron makers by the latter end of the sixties; nevertheless in 1873 and 1874 two more units were built at Hokendauqua. These were also of stone construction, but just why the management did not follow the advanced engineering of the times by using the iron shell on columns is an open question, unless there was some idea of retaining the symmetry of the original works.

In this connection, it is of interest to note that by the purchase, in the latter part of 1884, of the furnaces of the Saucon Iron Company at Hellertown, the Thomas company obtained possession of two of the earliest stacks to be built in this country of iron shells. Prior to the addition of the Saucon plant, the Keystone furnace at Island Park, near Easton, was acquired and it can well be imagined that by this time the Thomas company was an important factor in pig iron production. It is true that in the early eighties it led the United States in merchant iron output, and was outranked in Pennsylvania only by the famous Edgar Thomson plant, and that of the Cambria Iron Works. Additional production was accomplished through the lease of the Lucy furnace at Glendon about 1887, but as the unit was a small one it was not long retained by the Thomas interests. By reason of the commanding position of the company, its monthly quotations letters were for many years the means of establishing the eastern iron market.

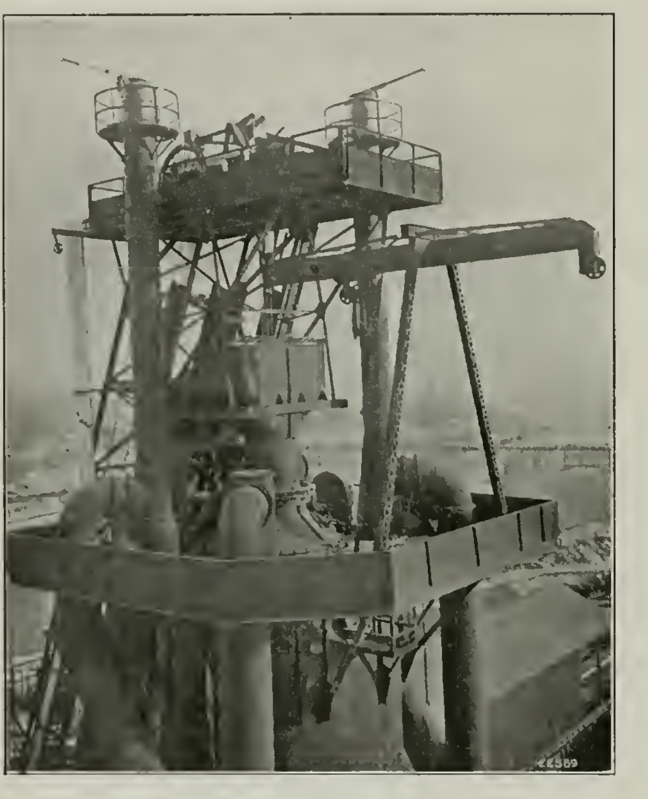

Fig. 2—View of furnace top, showing McKee Revolving Distributor, downcomers, etc.

At the close of the first half century of the career of the company, the number of operating furnaces had contracted to nine, with an annual output, however, of nearly 100,000 tons greater than in 1884. This fact was the result of the rebuilding of numbers one and three furnaces at Hokendauqua, so that this plant alone was able to produce more iron at this time than was made at all the works at the zenith of the career of the company, measured by the number of its furnaces. The first stack to be reconstructed was number one, which was accomplished by the tearing out of its twin unit, thereby making room for a modern steel shell of the day, with fire brick stoves added in 1897. Five years later the number three furnace was rebuilt in a similar manner, while the fourth old stone stack was abandoned. Fire brick stoves were used to replace the original iron type at number six stack, and after many years of good work there, they were removed to Alburtis to augment the equipment of that plant.

With the coming of the period of replacement of a number of small units by larger furnaces with increased outputs, the Thomas company followed the order of the day by concentrating their improvements at Hokendauqua. The remaining stacks of the stone stack era were abandoned and partially dismantled, and skip hoists replaced the hand-filling arrangements of numbers one and three furnaces. This improvement necessitated a rearrangement of the stocking system so long in vogue. The original layout of the entire plant consisted in having the stock houses and casting sheds parallel to each other, and at right angles to both the Lehigh Valley Railroad and river. This arrangement was satisfactory in the old days of light, close coupled equipment, but with the advent of modern ore and coke cars, the short curves gave considerable trouble. Each stock house was served by a bridge, carrying the tracks over those of the Lehigh Valley road, which was obviously an inadequate arrangement, with the further disadvantage of stock delivery on dead-end trestles.

The policy of the management of The Thomas Iron Company is to centralize their operating activities at the main plant at Hokendauqua, utilizing the outlying smaller units for special iron or for caring for abnormal demands of the market. One of the Saucon stacks has recently been torn down, and the Keystone furnace was sold during the war period to the Northern Ore Company, and the remaining units at Hellertown and Alburtis have been put in good operating condition.

Reconstruction of the Hokendauqua plant has made good headway by the recent completion of the rebuilding of the number three furnace, while plans have been made for eventually enlarging the number one stack, thereby centering the work done around the enlarged two furnace plant. Number three furnace as rebuilt is about 300 feet north of the remains of the old stone stacks, and about 150 feet south of the number one. The blowing engine house, boiler plant, and pig casting machine are along the Lehigh Valley tracks north of the furnace sites and the stoves, dustcatchers and gas washers are west of the furnaces, immediately adjacent to the railroad. The stock bins are east of the furnaces, and are reached by an elevated track crossing the Lehigh Valley tracks above grade at the north end of the plant.

The designing and rebuilding program was handled under a general contract by Arthur G. McKee & Company of Cleveland, Ohio, and was under the direct supervision of Mr. W. A. Barrows, Jr., President, and Mr. C. E. Hulick, Superintendent of The Thomas Iron Company.

The No. 3 stack was completely rebuilt from the foundation up. The foundation is concrete, octagonal in plan, with foundation bands of reinforcing rods, and measures 40 feet short diameter at the base. Eight feet of fire brick bottom blocks bring the hearth level 16 ft. above the general yard level.

The new lines of the furnace give a hearth diameter of 16 ft., a bosh angle of 79 deg. 55 min. and a height of 90 ft. from hearth level to top platform. The volume of the furnace is 17,745 cu. ft., and the total brick count in the lining 358,400 9-in. equivalents. The general arrangement of the furnace lines, top and skip bridge are illustrated in Fig. 1.

The hearth jacket is of 1⅛-in. plate, 9 ft. high, and the tuyere jacket of 1-in. plate 7 ft. 5 in. high. A steel plate bosh jacket was used, cooled by water sprays, eliminating most of the bosh cooling blocks customarily used, the former type of construction being considered preferable by The Thomas Iron Company. A new bustle pipe 4 ft. 2 in. in diameter was installed. The new furnace shell is of ¾-in. plate throughout, supported on a mantel ring of 1-in. plate, reinforced with heavy angles.

The furnace top is equipped with a McKee Revolving Stock Distributor with 5 ft. 6 in. small bell, and 11 ft. 3 in. cast steel large bell. The platform is roughly square in plan. Four downcomers of the McKee baffled type were supplied, with two bleeders and explosion valves. The top platform, distributor and downcomers are well illustrated in Fig. 2.

The upper platform for the bell operating rigs is supported on the upper end of the skip bridge. The bell cylinders are of the horizontal type, enclosed in structural frames. A 20-ton trolley was installed for handling the furnace distributor and bells. The increased height of the furnace together with the fixed location of the stock bins necessitated a very steep skip bridge. It is of the through truss type with ¼-in. deck plates and 60-lb. A. S. C. E. rails. Skip ropes are led through the bridge to the hoist engine directly below. Skip cars are of 100 cu. ft. capacity. The new hoist engine house is of brick on a concrete foundation spanning the hot metal running track. The new hoist engine has 12x14 in. cylinders with a 60-in. drum and was built by the Otis Elevator Company.

The Pugh type 75-ton hot metal ladle cars were provided. The new pig casting machine was designed and installed in a structure suitable for housing a second machine when found necessary. This machine, which is of the Uehling type, was manufactured by the Pittsburgh Coal Washer Company, and installed by the McKee Company.

Additional power requirements were met by the erection of five 514-hp. Connelly boilers. These boilers were designed for 160 lbs. working pressure and were erected in batteries of two, provision being made for the addition of three more boilers in the future. Boilers are equipped with Kling-Weidlein aspirating burners for blast furnace gas. Steam piping was installed by the shown in Fig. ... Steam piping was installed by the Pittsburgh Piping & Equipment Company as subcontractors under the McKee Company.

Three reciprocating boiler feed pumps were installed and a feed water heating of 6,000 hp. The pumping requirements of the water purification plant were met by the installation of two centrifugal motor driven pumps, each with a capacity of 1,000 gallons per minute. A water purification plant of sufficient capacity for the furnace plant was installed by the Wm. B. Scaife & Sons Company in buildings erected by the McKee Company.

Other additions and changes consisted of new buildings for pumps, new cast house, alterations to trestles, skip pit and bins, changes in gas mains, water and steam piping and other minor items necessary to make the plant modern and complete in every respect.

CONFERENCE ON NON-FERROUS ALLOYS

A conference of the Advisory Committee on Non-Ferrous Alloys of the Institute of Metals Division of the American Mining and Metallurgical Engineers with representatives of the United States Bureau of Mines was held at the Bureau of Mines, Washington, D. C., April 25. This was the second meeting held for the purpose of developing a program of co-operation between the non-ferrous metal industries, as represented by the Institute of Metals Advisory Committee, and the Bureau of Mines, with especial reference to the non-ferrous work of the latter organization.

The conference discussed the question of the functions and possibility of development of the proposed Alloys Research Association, now known as the Alloys Research Information Service. As originally proposed, it was the idea to receive contributions of $250 each from firms in the non-ferrous metal industry for promoting a central information service. A fund of $40,000 was required for this work, which would begin as an information and abstracting service and later develop into a central research laboratory. The feeling was that, owing to the depressed industrial situation, it would not be a propitious time to push the matter. Members representing industrial concerns stated that their companies would be willing to enter such an association when conditions are better.

The work of the Ithaca, N. Y., station of the Bureau of Mines on the effect of inclusions on the endurance of alloy steels was outlined by Dr. H. W. Gillett, who mentioned the rise of temperature test as a method for facilitating fatigue tests and showed the importance of the problem in both ferrous and non-ferrous metals.

The question of refractories for the Ajax-Wyatt furnace was brought up by William B. Price of the Scovill Manufacturing Company. It was stated that a number of companies were working on the problem, and it was suggested that their interests and information be pooled. The facilities of the ceramic section of the Bureau of Mines were offered as a clearing house for information in regard to refractories for the furnace.

Dr. R. B. Moore, chief chemist of the Bureau of Mines, outlined a proposed plan of investigation by the steel industry, the Bureau of Mines and the Bureau of Standards in regard to the effect of inclusions on the fatigue resistance of steels.

The desirability of investigating copper-lead alloys was discussed.

R. J. Anderson, metallurgist of the Bureau of Mines, outlined the results of recent work at the Pittsburgh experiment station in regard to (1) the contraction of aluminum alloys, (2) removal of stress in brass tubing, and (3) heat treatment of cast non-ferrous alloys.

Clyde E. Williams, superintendent of the Northwest experiment station of the Bureau of Mines, Seattle, Wash., gave an account of experiments made on preparing cast iron from sponge iron and steel scrap in the electric furnace, particularly as to the effect of various factors on the rate of carbon absorption.

W. M. Corse of the Monel Metal Products Corporation brought up the question of centrifugal casting and suggested that the investigation of the process might properly fall within the scope of the Bureau of Mines.

The Hot Rolling of Gears

Recent Development and Perfection of a Process Whereby the Successful Production of Gears by Rolling Blanks Heated to a Forging Temperature Is Made Possible.

By REGINALD TRAUTSCHOLD, M.E.
Consulting Engineer*

ALTHOUGH the reduction of gears has in the past been primarily in the province of the machinist, the recent development and perfection of a process based on a well known principle has brought it within that of the forger—through the successful production of gears by rolling blanks heated to a forging temperature. This accomplishment has long been recognized as theoretically possible and was attempted as early as 1872 by John Comley, who endeavored, but unsuccessfully, to mold gear teeth on a heated blank by a knurling process. Several more recent attempts to produce gears by the same or a similar process were equally unproductive of results, the failure in each case being due to the fact that the inevitable slippage which occurred was overlooked and no attempt was made to counteract it. In all these early experiments only one of the functioning shafts of the rolling apparatus was positively driven. As the rotation of the die roll was thus entirely dependent on that of the blank or vice versa, the resulting slip between the two caused serious distortion of the teeth on the molded gear and destroyed accuracy in tooth spacing.

The one additional factor necessary to the successful development and perfection of a gear rolling process was neglected until some 10 years ago when H. N. Anderson conceived the idea of positively actuating both of the functioning shafts and accurately synchronizing their rotation by means of suitable timing gears. Experiments with this improved apparatus conclusively demonstrated that it eliminated entirely the slippage between the die roll and the blank, and the resulting distortion which had caused the failure of previous attempts to roll gears. Mr. Anderson's idea in developing his process and constructing his first machine was merely to replace the preliminary gashing operation of the prevalent method of gear cutting and then to finish the gears by the usual grinding processes. However, the first machine, completed in 1911, not only proved successful in molding accurately spaced teeth, but also teeth so perfectly that any further finishing of the teeth was unnecessary. This initial achievement won for him the award of the John Scott Legacy Medal by the Franklin Institute in 1915.

The Die Roll Problem.

The problem of ultimate perfection of the process thus became primarily one of developing a system of die rolls which would form perfect and efficient gears with a high degree of accuracy at low cost and which could be redressed when necessary without affecting the precision of form of the molded teeth. The perfection of such a system of dies and their adaptation to use on a practical and efficient machine operating on the principle evolved have now made feasible the commercial production of gears by a true molding process.

The solution of the problem of dies offered little difficulty, as the plane sided tooth of the standard involute rack and the characteristic tooth of the standard crown gear, for rolling spur and bevel type gears respectively, met all requirements of economy and precision in production of the dies and of ease and economy in refinishing. These two forms proved readily adaptable for the production of all types of gearing in commercial use, and of several other types, such as the bevel herringbone, which is not possible of production by any cutting process.

The Rolling Process.

In the actual process of rolling gears, the blank, heated to a temperature of from 2000 to 2100 deg. F., is mounted on the work arbor of the rolling machine and securely clamped in place by means of a powerful automanipulation. The arbors carrying the die roll and the heated blank are actuated by suitable, heavy timing gears and the die and blank are rolled together in synchronized contact under a rolling pressure of from 10 to 20 tons. At the start of the rolling, the die is clear of the blank, but advances gradually until the teeth of the die have penetrated the blank to their full depth. This advancement is accomplished by means of smooth positive cam action which produces a regular constant progression of the die until very near the point of full penetration, and then a somewhat slower progression until the die and molded gear are fully engaged. The action of this cam mechanism is so timed as to effect full penetration of the die roll teeth just before the blank has cooled to its critical temperature and then to permit continued rolling with no die advancement until the blank has cooled somewhat below this temperature, the final stage of the process serving to planish and polish the teeth formed.

As the rolling is done, as a rule, at speeds varying from 400 to 700 revolutions per minute, it is obvious that the advance of the die roll per revolution is very slight. This fact assures a very thorough kneading and working down of the metal of the blank and permits the easy and free flow of the metal as it is displaced and built up by the die. The fact that both the die roll and the blank are positively driven and accurately synchronized assures the die teeth penetrating the blank radially at exactly the same point on each revolution, effectively guarding against any tooth distortion in the finished product.

Cooling the Dies.

During the rolling operation the die drill is cooled by a stream of water directed against its face at a point opposite to that of contact with the blank. This cooling, in view of the fact that the entire rolling consumes less than 15 seconds, prevents the temperature of the die rising above that easily bearable to the hand. The chilling effect of the comparatively cold, wet die roll on the hot blank causes a rapid contraction of the heated blank and consequent loosening of the forging scale as it is formed. The loosened scale is then thrown free by the centrifugal force due to the high speed of rotation of the blank. Since the rolling is continued until after the blank has cooled below the critical temperature, or in other words, until after the formation of forging scale has ceased, the finished gears are entirely free from scale and the formed teeth are not only perfectly shaped and unmarred by scale blemishes, but are highly polished on all contact surfaces.

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*The Anderson Rolled Gear Company.

No further finishing operations are required except on the bore and faces of the hubs and on the ends of the teeth. For these operations, which may be easily and semi-automatically performed on standard machines, the gears are chucked on the accurately rolled teeth, thus assuring perfect centering.

Oscillating Attachment.

In order to attain the highest degree of precision in the form of the teeth molded, machines designed for the production of the most accurate gears are equipped with additional mechanism for frequently and automatically reversing the rotation of the die and blank. This frequent reversing or oscillation, at somewhat reduced speeds, varying from 80 to 200 revolutions per minute, is maintained during the forming of the molded teeth and until the die is within 0.01 inch of full penetration. The action then automatically reverts to high speed direct rolling for the planishing effect. The oscillating methods tend to effect displacement and building up to a somewhat more equal and constant degree on both sides of the teeth than if rolling in one direction is maintained, thereby producing a more perfectly symmetrical tooth form.

Forms of Die Rolls.

But two forms of die rolls are necessary for rolling all types of gears in general commercial use. For all spur gears the adopted master form tooth is that of the standard involute rack, simply wrapped around the pitch circumference of the die roll, irrespective of the diameter or number of teeth. The high degree of precision attainable in the formation of these dies—they are the form most easily and accurately reproduced by mechanical means—assures a corresponding perfection in the teeth formed on the molded gears. The profile curvatures of teeth so molded obviously differ slightly from those of the standard involute system, thus sacrificing that theoretical advantage attributed to involute gears, of a slight axial adjustment without impeding the functioning of the combination. The loss of this advantage is, however, of small consequence as it is of little or no value in actual practice. In the first place, gears in actual use are almost invariably mounted on shafts in fixed positions; secondly, the inherent inaccuracies of cut involute gears are undoubtedly sufficient to destroy any practical advantage of possible adjustment. In any event this char-

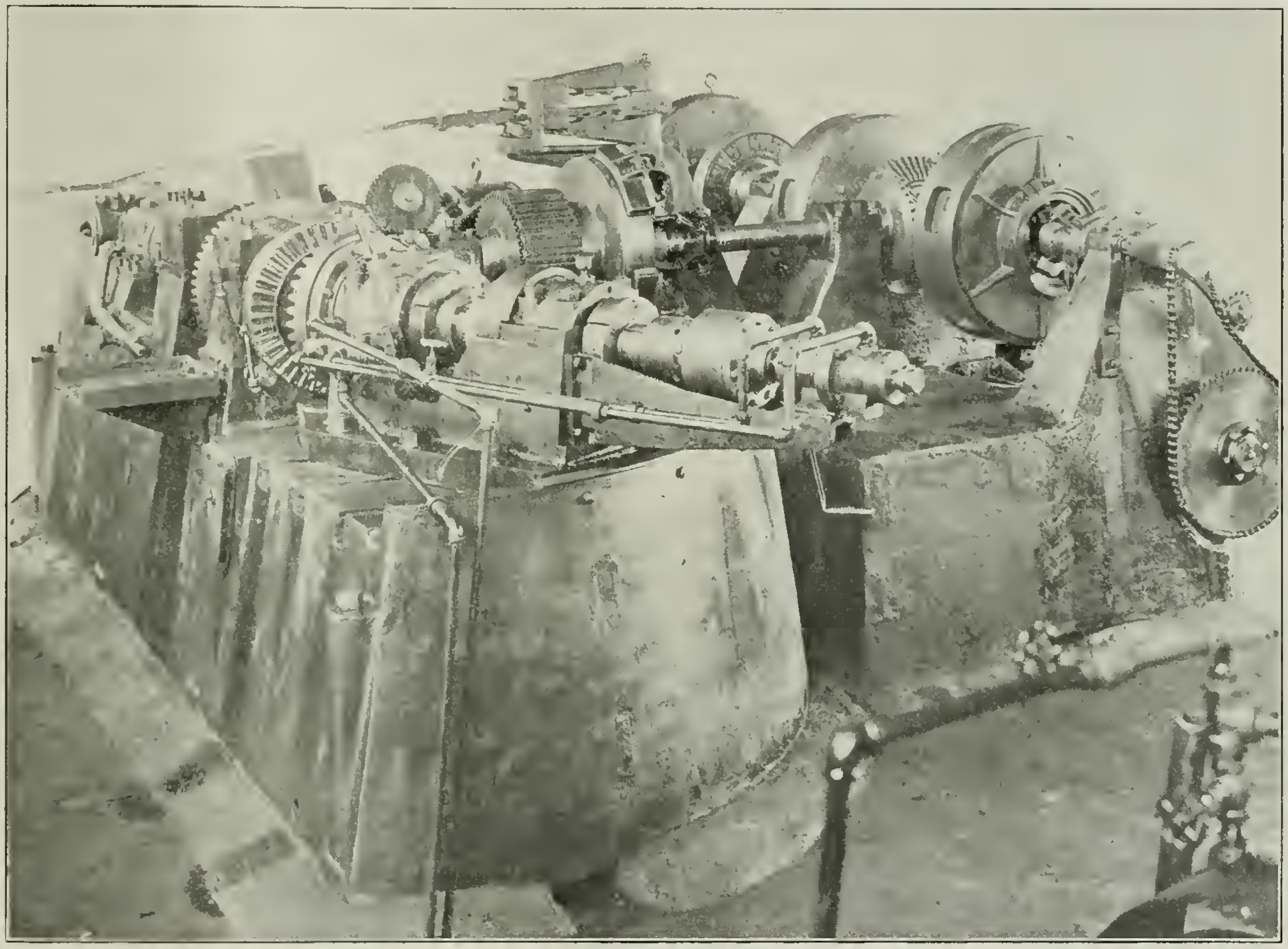

Fig. 1—Front and side view of bevel ring gear (K) machine.

acteristic is of negligible importance compared to the economic advantages of the simple die roll tooth design.

The master form of die tooth is applicable to the formation of helical or spiral spur gears by making the tooth spaces of the die in the form of oblique straight cuts across its face, although the resulting tooth spaces are somewhat deeper at the center than at the ends. On gears molded from these dies the teeth are, of course, somewhat shorter and heavier at the ends than at the center, but gears so formed are actually stronger than gears of the same pitch with teeth of uniform dimensions, as the great central tooth depth tends to increase the arc of contact at the center of the face.

Herringbone gears may be as accurately and cheaply produced as the other types by the simple expedient of a compound die roll, made up, to enable easy redressing, of two helical die rolls of opposite spiral angle, keyed and securely bound together when functioning, and readily taken apart for separate refinishing of the two halves. Accurate alignment of the two parts of these dies produces the monolithic teeth essential to maximum strength. Not only can perfect herringbone spur gears be formed by this method, but application of compound die rolls to bevel gear rolling produces as readily and as cheaply a bevel herringbone gear, which can be made by no other method, and may conceivably prove of even greater value in machine construction than the herringbone gear of the spur type.

For the production of all types of bevel gearing the crown gear form of tooth is used and in many cases a crown gear type of die roll. If, however, the gear to be rolled is to be of a given number of teeth of a certain pitch, such as the standard pitches now in general use, its diameter is also definitely fixed. As the diameter of a crown type die roll is established by the length of the conical element of the gear to be rolled, it is apparent that the circumference of the crown gear die roll may not be commensurably proportional to that of the blank. The crown gear die roll would not, therefore, accommodate a full number of teeth of the given pitch, but this may be overcome by the use of a flat bevel die roll, shortening the diameter of the die until it is commensurably proportional to that of the gear blank.

Die Roll Proportions.

As the actual operation of molding the plastic gear blank ceases when the blank has cooled to just below its critical temperature and before there is any appreciable increase in the temperature of the die roll, it is, of course, necessary to design and proportion the dies for molding gears at that critical temperature. Consequently, the dies must all be somewhat oversize as compared with the finished gears at normal temperatures. In designing the dies this allowance for shrinkage can be determined only empirically, but the laws governing the action of metals under variations of temperature and the coefficients of expansion have been so accurately established that a high degree of precision in proportioning the dies is possible, the gears produced being more accurate in spite of this shrinkage allowance than those produced by any of the cutting methods. Die rolls properly made and proportioned as above should produce at least 500 accurately rolled gears before any wear is apparent.

Dressing Die Rolls.

All types and sizes of die rolls having the master form of tooth can be very easily redressed whenever it is made necessary by wear. It might, however, seem that this redressing in the case of dies of the spur type would introduce inaccuracies in the product due to the inevitable slight reduction in the diameter of the die. This would undoubtedly be true if the speed of functioning shaft rotation were not controlled by the heavy timing gears, that is if the blank were not driven in synchronized contact with the die roll. As it is, the angular distance the teeth molded on the blank remains constant, regardless of any slight reduction of the diameter of the die or the thickness of the die teeth. The only effect of this modification, if appreciable at all, is to produce a slight creep between the die roll and the blank, which does not appreciably affect the profile curvature or the thickness of the molded teeth. Even a quite considerable amount of creep may be successfully absorbed by a reduction in the thickness of the die roll teeth sufficient to maintain a constant width of die roll tooth spaces.

This modification of die roll proportions in redressing is entirely unnecessary in the case of the crown or flat bevel type of die as the grinding does not affect the diameter of these types.

Shrouded Gears.

All die roll faces are somewhat narrower than those of the gear blanks, thus producing gears partially or wholly shrouded. Consequently, if it is desired to strengthen the weaker member of a pair of gears, the shroud may be left on, either entirely or partially, or the shrouds on the two gears may be so proportioned as to equalize the strength of the two and greatly increase that of the combination. The increase in strength cannot well be definitely established, but considering also the greater inherent strength of rolled teeth, it is probably a conservative assumption that shrouded gears can be proportioned and rolled which possess double the strength of ordinary cut gears of the same pitch.

Greater Inherent Strength.

The greater inherent strength of rolled gears is due to the effect on the structure of the metal of rolling at high temperature and under high pressure. This pressure and the thorough kneading action of the die teeth while the metal is in a plastic state, in addition to building up and compressing the metal into the formed teeth, gradually breaks up the normal coarser crystalline structure and produces a dense, thoroughly worked metal of almost fibrous characteristics. The minute crystals are rearranged in a truss formation following the periphery of the finished gear, thus tying the teeth to the body of the gear and equalizing the structural strains. In fact, the reduction of internal structural strains is so marked that no distortion whatever occurs in subsequent heat treament of the gears and it has even been found unnecessary to use any clamps to hold the gear true when quenching.

The modified metal structure also materially increases the hardness and wearing qualities of the gear teeth and assures a more uniform result from case hardening or other heat treatment. Exacting laboratory tests, confirmed by service tests under the most severe operating

	Machine Cut Gears	Hot Rolled Gears
Normal Condition		
Yield point	6470 lbs.	7918 lbs.
Ultimate strength	12250 lbs.	13645 lbs.
Hardness	22	26
Case Hardened		
Yield point	13529 lbs.	14750 lbs.
Ultimate strength	17250 lbs.	19130 lbs.
Hardness	87	85
Depth of case	0.027 in.	0.035 in.

conditions, have shown an average superiority for rolled gears of 25 per cent in strength and 20 per cent in hardness, as shown in the tables.

Economy of Gear Rolling.

In addition to the decided superiority in strength and hardness in the gear teeth produced, the process itself effects a very considerable saving in the cost of quantity production of gears, as compared with that of the approved cutting methods under even the most favorable of conditions. This saving applies in varying degrees to the cost of material, labor, overhead, and equipment investment.

As the rolling process is essentially one of displacement and building up, rather than of cutting away, of the metal, the blanks may be so proportioned as to require the removal of a minimum weight of metal in finishing the hubs of the gears and the ends of the teeth. The saving in actual weight of metal in the rough gear blanks thus effected ranges from 20 to 40 per cent of that scrapped from blanks for the same sizes of cut gears.

The largest machine so far developed can be easily handled by two men, an operator and a helper, the actual operation of the machine being entrusted to the operator, leaving the helper to tend the heating furnace, heat the gear blanks and feed them to the machine. Intelligent laborers under the direction of a capable foreman can readily be trained to the efficient performance of either function. When it is realized that the actual time of rolling the largest gears is less than 15 seconds, the saving in labor costs by the rolling process may be appreciated. It is only limited by the degree of dexterity attained by the crew and a production rate of 80 or 90 finished gears per hour can be readily attained and maintained. The time saving in the actual tooth forming operation alone, over the fastest method of accurate gear cutting, is from 90 to 95 per cent or even higher, while the saving in the production of completed gears ranges from 20 to as high as 80 per cent.

This advantage in rate of production effects, as well, a very substantial saving in initial equipment investment—the average being 50 per cent or more for all equipment necessary to finish the gears completely and about 75 per cent for the equipment needed in simply finishing the gear teeth. For a daily production, such as might be needed by a large manufacturer of automobiles, of 700 bevel ring gears, 700 bevel pinions, 700 miter bevel gears and 1400 spur gears, for example, the following figures showing the actual cost of the equipment necessary, demonstrate the magnitude of the saving effected by the rolling process.

TOTAL EQUIPMENT COST

Cutting Process	Hot Rolling Process	Saving
$508,500.00	$234,050.00	53.97%

TOOTH FORMING EQUIPMENT ONLY

Generating and Gashing Machines	Furnaces and Rolling Machines	Saving
$362,500.00	$91,500.00	74.76%

This saving is obviously due, for the greater part, to the smaller number of machines required to maintain any given rate of production by the rolling process and is reflected to a proportional degree in the saving in the floor space or the investment in buildings required. This is in itself no inconsiderable factor, particularly where existing plant facilities are inadequate.

To sum up the economies accomplished by the Anderson process of gear rolling—the saving of about 50 per cent in equipment investment, the 25 to 80 per cent reduction in labor costs and the 20 to 40 per cent reduction in waste material, combine to produce a saving in the total cost of production of completed gears amounting, at a conservative estimate, to from 20 to 40 per cent.

As the rolling process is essentially a true molding and a true development process, while the most accurate and efficient cutting method, the generating process, consists of two entirely unrelated movements, rotation of the blank and intermittent transverse cutting action, which can not be absolutely co-ordinated, it is obvious that rolled gears must inevitably possess a greater degree of accuracy and symmetry of tooth form and smoothness of finish. These factors directly affect the wearing qualities and efficiency in power transmission attainable in gear trains, which, considered in conjunction with the very material decrease in the cost of production and the gain in structural strength of from 25 per cent to as high as 100 per cent, in the case of shrouded gears, would seem to justify the assumption that the Anderson process promises to attain universal adoption wherever economy in quantity production of accurate gears is desired, and eventually to improve greatly the finish, wearing qualities and efficiency of gears in general commercial use. In fact, Mr. Anderson's invention of a practical gear rolling machine and the development of it, as now attained, undoubtedly represent one of the most revolutionary developments in the mechanic arts in recent years.

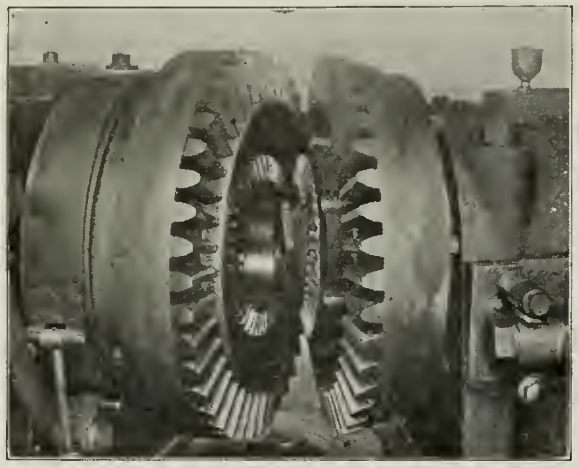

Fig. 2—Die, blank and timing gears, bevel ring gear (K) machine.

INFORMATION REGARDING TECHNICAL SOCIETIES.

The frequency of requests for information concerning scientific and technical societies has emphasized the need for a source from which this information may be quickly obtained.

The Technology Department of the Carnegie Library of Pittsburgh is meeting this need through maintenance of a card file of national societies of this type. The cards, in so far as the information is available, contain the official name of the society, the names and addresses of president and secretary, date of annual meeting, and the official "organ," or publication. A supplementary file lists those serials which regularly publish advance notices of national, state and local meetings.

It is desired to make this file complete for all scientific and technical societies in Pennsylvania and to include all sections of national and state societies having headquarters in Pittsburgh. To this end, the co-operation of local secretaries is urged. Please send information to E. H. McClelland, Technology Librarian, Carnegie Library of Pittsburgh.

Control of Silicon in the Blast Furnace

Discussion Showing How the Composition of the Iron Is Regulated by Varying the Composition in General of the Charge and by Controlling the Temperature of the Hearth.

By S. L. GOODALE
Professor of Metallurgy, School of Mines, University of Pittsburgh

EVERY modern blast furnace is operated to produce some definite kind of iron at any particular time. In order to maintain the furnace product within the narrow range of composition required for each particular use it is necessary to maintain the operation of the furnace uniform within very narrow limits.

The controlling factors in regard to kind of iron to be made are the temperature of the operation—and this refers mainly to the temperature of the hearth where the finishing reactions occur—the composition of the raw materials used, and the proportioning of the various ingredients of the charge. And when all of these factors are right to produce the desired iron it is furthermore very necessary that they should be kept right so that the furnace shall continue to operate uniformly and not be subject to changes of conditions. The commercial requirement of low cost must always be strictly observed. We will discuss certain of these controlling factors, first taking up a number of mechanical phases that contribute to the uniformity of operation, and then taking up the chemistry of the process and discussing how the composition of the iron is regulated by varying the composition in general of the charge, and by controlling the temperature of the hearth, and explain some matters concerning temperature control. By the term hearth is here meant all and only that part of the lower inside volume of the furnace where the coke is being actively burned by the blast and the iron and slag are melting. The lowest portion inside where iron and slag collect may be distinguished by the term crucible.

The basic principle of the blast furnace may be said to consist in the subjection of the iron ore to the action of certain reagents at temperatures gradually increasing up to that of the hearth. The chief reagents employed are the carbon monoxide formed by combustion of the carbon of the coke with the oxygen of the blast, the carbon of the coke acting directly, and the slag forming portions of the charge. Two main objects are sought, first, to produce pig iron of the composition desired, and at the lowest unit cost possible, and, second, to eliminate the gangue, or surplus material which occurs naturally with the ore, limestone and coke, as cheaply as may be. This latter requirement necessitates the fusion of all this material into a slag as the only practicable way of handling it.

The mechanical control of the process referred to is directed to securing the thorough interaction of the stream of gases rising in the furnace with the slow stream of solid and liquid materials descending through the same space. Channeling must be avoided. The charging of the furnace must follow a regular routine which will secure such a distribution of the various sized particles of the charge over the top of the charge column as to start the material down through the furnace with practically the same open area for the gases to pass through in any one part as in any other. This distribution must be correct in two ways, first, radially, and, second, circumferentially. Good distribution is not always easy to secure, although much effort has been expended on this matter and the apparatus in use has been developed through years of experimenting and study.

It is also advisable to have the materials of the charge in such a state of physical division that they will work their way fairly regularly down through the furnace, this meaning that the pieces charged should be neither too large nor too small, but of about a similar size throughout. It is bad, and may be disastrous, for certain parts of the charge to be so fine as either to be blown out of the top of the stack by the blast of gases, the gases having a very high carrying power for dust at that point because of their high velocity, or to run ahead of the other parts of the same charge because of being so fine as to slip down through between the larger pieces of stock. Some materials tend strongly to run ahead, in fact, certain fine dry powdered material will flow almost like water, especially when hot.

It is as necessary to distribute the blast over the full area of the hearth as it is to distribute the solid charges over the full area of the throat of the furnace. A good distribution of the blast is much more nearly obtained by the original design of the furnace being fitted to its expected operating conditions than is a good charge distribution. The blast must penetrate to the center of the furnace at or nearly at the tuyere level, and this is a distance of 10 feet in some large modern furnaces. This space, moreover, is occupied with a mass of solid coke.

We will assume that these mechanical features have been so controlled that all parts of the charge reach the various levels of the furnace on their way from the top to the hearth together as charged, except that, whereas the charge was introduced in layers of, say, coke first, then stone and then ore, when the charge has gotten a few feet down into the furnace these layers will have mixed more or less. We will further assume that the stock is everywhere distributed so as to be uniformly acted on by the gas over the whole of the area of each level, and that the blast and gases are also uniformly distributed in a similar way to act on the charge.

Then the purpose of this paper is to set forth briefly some of the fundamental chemistry of the process, and how this may be utilized to control the operation to secure a desired result, and particularly with regard to silicon. In a later paper it is intended to set forth something of the effect of silicon in the iron itself, and of the reasons for the importance of this element.

The fundamental chemistry of the operation can be stated roughly in a broad, over-all sort of way in a series of fairly definite typical reactions which consider only the raw materials and the finished products, or the products at some fairly definite stage of the operation. For the present purposes we may deal with certain parts of the chemistry in about this way. In the upper part of the shaft of the furnace most of the reduction of the iron oxides of the ores to iron is accomplished, and this is mostly done by the carbon monoxide taking up this oxygen from the oxides of iron and becoming carbon dioxide with a considerable evolution of heat. In some cases of easily reducible ores the reduction of the iron oxides to iron is practically complete within the upper levels—perhaps the upper fourth—of the shaft; in other cases a notable part of these reductions is left to be completed at the higher temperature and in the purer carbon monoxide of the hearth. Still other furnaces will run with intermediate conditions in this respect.

These typical reactions may be formulated about as follows, but it should be remembered that the reactions as stated are only types, and are not to be thought of as giving in any complete way an idea of what goes on.

1.	250°C.	$Fe_2O_3 + 3CO \longrightarrow 3CO_2 + 2Fe$	
2.	250°C.	$2CO \longrightarrow CO_2 + C$	
3.	250°C.	$Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$	
4.	400°C.	$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$	
5.	550°C.	$C + CO_2 \longrightarrow 2CO$	(rapid)
6.	600°C.	Deposition of carbon ceases.	
7.	700°C.	$FeO + C \longrightarrow Fe + CO$	(begins)
7.	800°C.	$FeO + C \longrightarrow Fe + CO$	(complete)
8.	800°C.	$CaCO_3 \longrightarrow CaO + CO_2$	
5.	1000°C.	$C + CO_2 \longrightarrow 2CO$	(prevails)

CO_2 cannot exist below the level of this temperature.

Smelting	9	$SiO_2 + 2C \longrightarrow Si + 2CO$	
Zone	10	$FeS + CaO + C \longrightarrow CaS + Fe + CO$	
	11	$MnO_2 + 2C \longrightarrow Mn + 2CO$	
	12	$P_2O_5 + 5C \longrightarrow 2P + 5CO$	

Table adapted from Stoughton's "The Metallurgy of Iron and Steel."

This deoxidaton of the ore oxides takes place in accordance with the chemical law of mass action, etc., and to an extent which depends on the time during which the reagents act. When we have at a high temperature a mixture of iron ore, carbon and air or the products of combustion of carbon with a limited amount of air this law of chemistry teaches that the materials will tend to react with each other until there is a certain ratio between the amounts of carbon monoxide and carbon dioxide present, which will be unchanged so long as the temperature and pressure are maintained, and unless or until any of the reacting substances is used up.

In general, those reactions will take place between the elements of any reacting group which will result in the production of the greatest amount of heat whenever heat can escape from the place where the reaction occurs or be absorbed in some way. But when heat is supplied in sufficiently large amounts from some outside source or from another more powerful reaction the reaction can be forced to proceed in the opposite direction, i. e., so as to absorb heat. In this case that reaction, of several that are possible between the reagents present, will occur first which shows the least absorption of heat; and then as the temperature increases or the supply of heat becomes greater the more difficult endothermic reactions will start, i. e., those absorbing more heat.

Figures are tabulated below to show the relative amounts of heat given off when various elements unite with a unit weight of oxygen. These figures are given as a part of the basis for the discussion of the reduction of silicon from the silica in the charge; and are put on the basis of the same weight of oxygen in all to show the relative affinity of the various elements for oxygen, the affinity being proportional, other things being equal, to these quantities of heat.

Element	Weight	Oxygen	Heat Cals.	Compound	Weight
C	.75	1	1823	CO	1.75
C	.375	1	3038	CO_2	1.375
CO	1.75	1	4253	CO_2	2.75
Fe	3.5	1	4106	FeO	4.5
Fe	2.63	1	4231	Fe_3O_4	3.63
Fe	2.33	1	4075	Fe_2O_3	3.33
Mn	3.44	1	5681	MnO	4.44
P	.775	1	4566	P_2O_5	1.775
S	1.00	1	2164	SO_2	2.00
Si	.865	1	6125	SiO_2	1.865
Al	1.125	1	8179	Al_2O_3	2.125
Ca	2.5	1	8219	CaO	3.5
Mg	1.5	1	8963	MgO	2.5

Table figures taken from Richard's "Metallurgical Calculations."

The exact meaning of the figures in the table may be made clear by explaining the method for obtaining the figure for the carbon uniting with an excess of oxygen to form carbon dioxide. The operation of determining this figure is exactly similar to the determination of the heating value of a sample of coal in a bomb calormeter. We cause the reaction to take place between, say, 1 gram of carbon and the necessary amount of oxygen under a high pressure in a heavy steel bomb with the bomb immersed in a measured amount of water. When the carbon is ignited CO_2 gas will be formed explosively at a very high temperature and then will be cooled rapidly by the heavy water-cooled steel bomb. We measure accurately—to the thousandth of a degree if desired—the rise in temperature of the water as soon as the water and bomb are at the same temperature. As 1 calorie is absorbed by each gram of water in being heated 1 degree it is easy to determine just how much heat has been absorbed by the water and the bomb; and this is the equivalent of the heat given off by the reaction, care being taken that no heat is lost or absorbed from other sources during the experiment.

In the above case all the heat given off is utilized to heat the bomb and water in the calorimeter, the quantity of water being taken so large that this change in temperature will be only a very few degrees. The gaseous products of the combustion which at first absorbed this heat gave up the heat and were cooled thereby almost down to the temperature of the carbon and oxygen at starting. In most actual cases of combustion the heat evolved is taken up by the gaseous products of combustion and is transferred from these gases by radiation, contact conduction and in other ways to any material which it is desired to heat thereby, the transfer of heat, however, seldom being 100 per cent efficient.

Heat can be transferred only from a body at a higher temperature to bodies at lower temperatures. The rapidity of transfer of heat from one body to another is greater the more the difference in temperature between the two bodies. A hot body radiating heat to a cooler body is not able to bring the cooler body up to its own temperature because—even if no heat is lost to any other bodies—as the hot body gives off heat it cools, and as the originally cooler body absorbs the heat it becomes hotter, and finally—if no heat is lost—the two bodies will arrive at a common temperature somewhat hotter than the originally cool body and cooler than the originally hot body.

To go back to the figures of our short table we may put their meaning in this way, that if a unit weight of oxygen be caused to react with the weight shown of any other element, both oxygen and element being at laboratory temperature and the resulting oxide be cooled again after the reaction to room temperature, then the tabulated figure shows the heat resulting from the reaction and which can be absorbed in a properly built calorimeter, the products of combustion being cooled therein to the initial temperature of the reacting materials or nearly so. In most cases of practical combustion this is not the amount of heat available from the combustion for the industrial operation, inasmuch as usually the gases formed pass away without being thoroughly cooled and thus giving up the heat evolved in the reaction to the material it is desired to heat. The amount of heat industrially available is only that which can be secured from the gases of combustion by cooling them down as far as may be and transferring the heat to the body we wish to get hot. Obviously it is not possible to cool the gases to a temperature below that which is contained in to heat this body.

The above discussion is introduced at some length in an attempt to bring out clearly the quantitative relations with respect to the development and use of heat in the blast furnace, and particularly as this bears upon the reduction of silicon. In order to abstract oxygen from any oxide it will now be clear that it is necessary to supply the amount of heat shown in the table in order to make that reduction possible, and there must usually also be supplied some other element to unite with the oxygen. This heat must be supplied in addition to the heat that is necessary to maintain the temperature high enough to permit or to cause the reaction. Under these conditions, the reduction will proceed faster, the faster the surplus heat is supplied.

The combustion in the hearth of the furnace is very rapid because of the high temperature and the high pressure, and takes place about in the following fashion: The hot blast meets very hot coke just inside the tuyeres, and as fast as contact is made between oxygen and carbon, carbon dioxide is formed which passes to the inner and higher portions of the hearth, and there meeting with additional coke reacts rapidly to form carbon monoxide. In this way all the oxygen of the blast combines with carbon of the coke to form carbon monoxide and produce an extremely high temperature within a short distance from the tuyeres and throughout the hearth. The coke burned away is replaced by fresh, hot coke settling from above, so that in effect at any instant there is always an excess of coke with respect to the blast. The nitrogen of the blast merely absorbs a part of the heat given off by the combustion and bodily transfers it to the higher levels in the furnace as sensible heat.

Let us study next how the heat produced as above will be absorbed by the descending solid stock and what chemical changes will be caused in this stock by this great heat. To do this we must assume arbitrarily figures for various temperatures, which may or may not be very accurate for any particular case, but will at least form a useful basis for study. We will assume, then, that the blast is heated to 600 deg. C., and that the coke in the hearth has been heated by the previous combustion to 1650 and figure how much heat will be produced by the reaction $C + O = CO$ if the CO formed is supposed to be cooled to 1650. The intermediate stage of the reaction to CO_2 does not need to be considered for the effect is very similar to what would be the case if the reaction were directly to CO, which it is for a considerable part of the burning. The effect of the nitrogen will need to be considered, since the nitrogen affects the temperature reached very materially.

Each unit weight of oxygen will absorb 133 calories in being heated to 600 in the stoves. The .75 unit weight of carbon will contain 528 calories when it is heated to 1650. If we add to these amounts the heat given off by carbon burning to CO at ordinary temperature, i. e.,

$$\begin{array}{r} 133 \\ 528 \\ 1823 \\ \hline 2484 \end{array}$$

We will have the total amount of heat present and that will be absorbed by the 1.75 units of weight of the very hot CO. If this CO gas be cooled to 1650, the temperature assumed in the hearth, the gas itself will retain the amount of heat required to heat it from room temperature to 1650, and only the surplus over this will be available in the hearth for increasing the temperature or for other thermal work. 1.75 units weight of CO will absorb 790 calories in being heated to 1650. This subtracted from the 2484 obtained above, because the CO carries this heat to higher levels in the furnace as sensible heat, will leave 1694 calories produced by the combustion and available in the hearth for each unit weight of oxygen burned. That is, this 1694 calories will be actually absorbed at the instant of combustion by the carbon monoxide and nitrogen, and these gases will thus be raised to a temperature much above 1650, and being hotter than the coke and other surrounding materials, will immediately begin to heat them by contact, radiation, etc.

The above figures neglect the effect of the nitrogen in the blast, which, however, must be considered because of the temperature. The weight ratio of oxygen to nitrogen in air is very nearly 3:10. Three and one-third parts of nitrogen heated to 600 in the stoves will bring in an additional 506 calories; but the same nitrogen is further heated to 1650 along with the carbon monoxide, and the heating from 600 to 1650 will absorb 1011 calories which must be provided from the 1694 calories above calculated. This leaves $1694 - 1011 = 683$ calories available for thermal work at a temperature above 1650 in the hearth. The mixture of 1.75 parts CO and 3 1/3 parts nitrogen rising into higher levels of the furnace at 1650 will carry $790 + 1517 = 2307$ calories as sensible heat.

Not all of the 683 calories of surplus heat above 1650 will be used for heating the descending material; but a considerable portion of it will be absorbed in endothermic chemical reactions. Endothermic reactions are caused to take place by supplying heat to a mixture of material which can thus react, and the reaction will proceed in proportion to the rate at which the excess heat is actually supplied.

Let us now return to our figures for the heats of reaction of the elements with oxygen, and study the reductions in the blast furnace on that basis. In order to make this study very clear as applied to silicon let us take up all the more important reductions in order beginning with the easiest, that of the iron oxides.

It will be observed that the heats of oxidation of iron to its various oxides fall between 4075 and 4231 calories per unit weight of oxygen, and that the heat evolved by

CO burning to CO_2 is slightly greater than any of these figures, viz., 4253 calories. This will explain the net evolution of heat observed in the upper shaft levels of the furnace as a result of reduction of iron oxides by carbon monoxide. The direct reduction of any of the oxides of iron by carbon burning either to CO or to CO_2 is evidently endothermic, since the carbon burning even to CO_2 only yields 3038 calories as against the lowest amount called for by any oxide of iron, viz., 4075 calories. This deficiency of heat is supplied by the heat in the hot gases in the shaft of the furnace to whatever extent the reduction is performed by solid carbon rather than by carbon monoxide.

The greater difficulty in reducing manganese is explained by its greater heat of oxidation. A sufficient surplus of heat at a high enough temperature to cause the manganese to be reduced is not encountered to any appreciable extent above the hearth of the furnace. Even in the hearth an appreciable portion of the manganese present usually escapes reduction and enters the slag.

The sulphur with its low heat of oxidation should be easily reduced, and when in the elementary condition will unite with iron or manganese or lime or other base if such a base with a high affinity for sulphur be present in the elementary condition. Lime is such a base, but its heat of oxidation is very great, and to reduce lime a very considerable surplus of heat must be available to force the strongly endothermic reaction. The heat of reaction between the lime and the sulphur itself assists here very much, and the amount of heat actually needed is not as great as appears from studying the oxide heats alone. The following heats of formation of the sulphides per unit weight of sulphur will assist to explain this matter.

CaS	2947
FeS	750
MnS	1425

The reaction for forming lime sulphide is usually written, the figures immediately beneath the various compounds being the heats of formation for the quantity of compound appearing in the reaction per unit weight.

$$\underset{1500}{FeS} + \underset{8219}{CaO} + C \longrightarrow Fe + \underset{5894}{CaS} + \underset{1823}{CO}$$

If we add together the heats of formation of FeS and CaO, and subtract from this sum the sum of the heats of formation of CaS and CO, the difference of 2002 calories will be the amount of heat required for this reaction instead of 6396 calories which is the difference in the heats of formation of the oxides of lime and carbon alone. Since sulphur in the above reaction is twice the weight of the oxygen in the same reaction, and the above figure is based on the unit weight of oxygen, it will be seen that the heat absorbed by the reaction per unit weight of sulphur is approximately 1000 calories, which is not a serious drain on the heat supply in the hearth, considering the small amount of sulphur usually actually present.

Silicon has a very high heat of oxidation as compared with iron or manganese, viz., over 6100 calories compared to slightly over 4000 for iron and about 5700 for manganese. The reaction for reduction of silicon is usually written

$$\underset{6125}{SiO_2} + 2C \longrightarrow Si + \underset{1823}{2CO}$$

6125 calories are absorbed to break up the silica and 1823 are evolved in the formation of CO from the oxygen so set free and carbon of the coke, leaving some 4302 calories to be supplied. Now it is only in the hearth of the furnace that a high enough temperature exists to cause this reaction to take place at all. There is a critical temperature below which it seems not to be possible to reduce silicon by means of carbon; and above this temperature the reaction can occur only so fast as the surplus of heat is supplied which amounts to some 4302 calories per unit weight of oxygen or 4920 calories per unit weight of silicon involved.

This matter of critical temperature for the reduction of silicon is of sufficient importance to emphasize strongly. Below this critical temperature, which is at about 1450 deg. C., if we have both silicon and oxygen together under the proper conditions in an oxidizing atmosphere it seems that the silicon will oxidize in preference to carbon, while if conditions remain the same otherwise but the temperature be raised to above the critical point the carbon will oxidize in preference to silicon. This is observed in a very interesting way in the Bessemer process. When the blow is started the iron is considerably below a steel melting temperature and the silicon burns in the early part of the blow. Because of the high heating power of the oxidation of silicon the temperature would rise to a point where the carbon would burn instead of the silicon and leave a carbon free, high silicon blown metal. The excess heat, however, is used commercially to melt some cold pig or scrap and so hold down the temperature to such a point as to secure the blown metal practically free of both silicon and carbon.

The same facts apply in the blast furnace as in the Bessemer converter, but their application is a little different. When the temperature in the blast furnace is maintained above this critical point then silicon is reduced from silica. We calculated above that the reduction of silicon required 4302 calories per unit weight of oxygen concerned; this corresponds to some 4920 calories required per unit weight of silicon reduced. We also calculated that under certain arbitrary conditions the combustion of carbon to carbon monoxide in the hearth produced a certain surplus of heat, which under the conditions assumed amounted to about 683 calories per unit of oxygen from the blast at a temperature above 1,650. This corresponds to some 910 calories per unit of coke; from which it is clear that the surplus heat production from some 5.4 units of weight of coke is required for the heat absorbed in the reduction of 1 unit of weight of silicon. This is probably fairly close to the amount of coke actually required in the furnace for this purpose.

The other conditions which affect the reduction of silicon are the amount of slagging bases in comparison to the amount of silica, and the amount of silicon in the iron. The silicon unites with some of the iron to form the compound FeSi which dissolves in the iron. The heat of this reaction and solution is probably not very great but it assists slightly towards the reduction of silicon from silica. The heat of solution of silicon in iron decreases rapidly as the amount of silicon in the iron increases. This and other factors act to make it increasingly difficult to secure an added unit of silicon in the iron as the amount of silicon already in the iron is greater. A basic slag tends to hold silica as such much more strongly than an acid slag.

One of the important means by which the temperature of the blast furnace hearth is maintained at a high level is by means of slag composition, viz., by keeping the mixture of slag forming materials such that it will not fuse down into a limpid liquid except at a high temperature. The result of this is to hold the material in the stream of superheated gases a longer time until it does attain the higher temperature necessary for fusion. While the material is thus held at the high heat and in the presence of carbon monoxide and in contact with coke the conditions are attained which are needed to reduce silicon.

The reactions outlined oppose each other to some extent. As silicon is reduced less silica is left for the lime and other bases, and the slag becomes less fusible. But as this action increases the affinity of the more basic slag for silica increases and it becomes more difficult to reduce further silica. The various reactions proceed toward the equilibrium conditions as far as time permits. That is, each particle of silica settling through the hot zone of the furnace is exposed to the action of the hot carbon, carbon monoxide, lime and other materials. It will go through as silica or be reduced to silicon according to which influence is the stronger and about in proportion to how much stronger that influence is.

If the blast furnace manager desires more silicon in his iron he will proportion the charge mixture to get more silica. He will adjust the amount of limestone so as to form a slag with the silica to be left as such which slag can be expected to have the right fusion temperature. He will regulate the blast temperature to assist in giving the high temperature desired in the hearth; and he will further watch carefully the operation of the furnace in general to secure that uniformity of running which is essential for a commercial furnace.

Electric Brakes For Steel Mills

It Is More Desirable Practice to Retard and Stop Loads Electrically by Dynamic Braking and to Utilize the Friction Brake Largely for Holding.

By GORDON FOX*

An electric brake is a friction grip which is set by mechanical means and released electrically. Some brakes are set by gravity through the medium of a weight attached to a lever arm, others are set by springs. Release is ordinarily accomplished by an electric magnet or solenoid, but a small motor is sometimes employed. Most brakes are applied to an extension to the armature shaft as being the most effective point.

The function of an electric brake may be either to retard and stop a motor and machine, to hold a machine at rest against a force or both to stop and to hold. A brake must be dependable because, if it fails, life may be jeopardized or property seriously damaged. It must therefore have a high safety factor.

Brakes may be classified according to their mechanical design. The common types are, the band brake, the disc brake and the shoe type or post type brake. Brakes may also be classified according to their use on direct current or alternating current systems.

The band brake is a familiar type, consisting of a flexible band encircling the brake wheel. This band is lined with a woven friction material or with wood or composition friction blocks. The band is usually anchored at one end. The other end is drawn tight by a weight or spring which, in turn is released by the solenoid. The band brake is a simple type. It has the advantage of large friction area as nearly the entire wheel circumference is encircled. It serves very well as a holding brake particularly against a force always in one direction. A band brake exerts more torque in the wrapping than in the unwrapping direction of rotation, the latter being one-third to one-half the former. A band brake causes a side thrust to be exerted on the shaft as the pull is largely in one direction. It is somewhat difficult to maintain clearance at all points around the brake wheel due to slight eccentricity and irregularity in the band, hence the opening movement must be considerable. Band brakes are commonly operated by solenoids having a fairly long travel. These solenoids may be actuated by either direct or alternating current.

The disc type brake consists of a series of non-rotable plates or stages alternating with a series of rotating plates. The stationary plates are machined surfaces. The rotating plates are loosely keyed to a hub mounted on or connected to the motor shaft. They are lined on both sides with friction material. The stationary and rotating plates are pressed together by a spring and are released and separated by a magnet. Fig. 1 shows a brake of this type attached directly to a crane motor.

The principal advantages of the disc type of brake are its compact construction, its relatively light weight and its quick action. This type of brake requires very little room perpendicular to the shaft and little head room. It has little inertia due to the light weight of its revolving parts. It has a large wearing surface area. It is at a disadvantage in that the brake must be moved or dismantled in removing an armature. It is a little more difficult of alignment. It cannot readily be released by hand. The friction surfaces are enclosed, are somewhat inaccessible for inspection or repair and the heat dissipating ability is restricted. Ventilation is provided to minimize this difficulty. The enclosure of the friction surfaces protects them from oil and from the weather. The disc brake can be mounted on the end of a shaft only. It cannot be well adapted for alternating current.

The shoe type brake is probably the most commonly used. It consists of a brake wheel and two shoes which are attached to levers. The shoes are made to clamp the wheel, either by weights or springs acting on the levers. In some types there is a more or less complicated linkage of levers. The shoes are released either by a solenoid or by a magnet acting through the levers.

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*Electrical engineer, Freyn, Brassert & Co., Chicago, Ill.

The shoe type brake is both rugged and accessible. It introduces no end thrust or side thrust. It is usually attached to the armature shaft extension but may be attached to a central portion of a shaft. This type of brake may be arranged to permit easy removal of the armature. Shoes brakes are commonly 30 to 40 per cent heavier than band or disc types. They require a comparatively powerful solenoid. They have a minimum area of wearing surface. The friction surfaces are exposed to the weather. Some designs are rather bulky and require considerable space alongside and head room above the motor.

There are many designs of shoe type brakes differing considerably in their principal features. Fig. 2 shows a brake which is set by gravity and released by a solenoid. This type of brake is well adapted for use with a dash pot. Cut out devices mentioned later may be readily applied. The coil is enclosed and fully protected.

There is considerable inertia in the moving members in a gravity actuated brake, tending to delay initial movement and tending to cause rather sudden clamping action. In any solenoid brake there is some magnetic lag and there may be friction between the plunger and the bore of the solenoid. Fig. 2 shows a shoe brake which is actuated by springs, a magnet being used instead of a solenoid.

A large number of levers in a brake mechanism is undesirable because of complexity and there is more or less wear at the hinge pins depending upon the amount of pressure and movement. This leads to friction and lost motion. Fig. 4 shows a simple shoe type brake employing a minimum of parts. The brake is set by a spring enclosed within the magnet housing. It is released by a large, short stroke magnet. This brake is exceptionally compact, and requires little head room. The short stroke affords quick action and the comparative absence of inertia eliminates shock on setting or hammer on release. The brake can be easily dismantled for removal of the armature without affecting its adjustment. The magnet coil is enclosed and protected. This brake is adapted for direct current only.

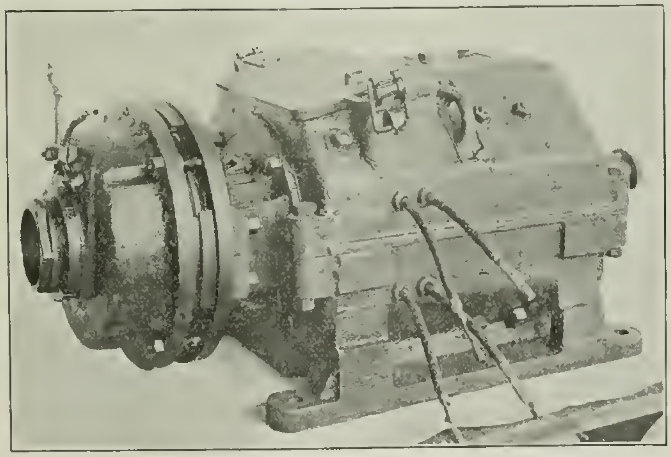


Fig. 1—Disc brake attached to crane motor.

The majority of direct current brakes are wound with relatively few turns of heavy wire and arranged for connection in series with the motor. The most obvious reason lies in the fact that a coil thus connected is automatically deenergized and the brake released when the current is shut off. There are other contributing causes for preference of a series brake where applicable. In the case of a crane, an extra trolley bar and collector would be required if a shunt brake were used. With a series brake there is definite assurance that when the brake is released the motor has current to hold the load. A shunt brake might be released even with the armature circuit open and no holding torque developed. The coil of a series brake contains fewer turns of relatively large wire and is therefore more rugged and dependable. The series wound solenoid acts more quickly than the shunt coil in releasing and setting the brake.

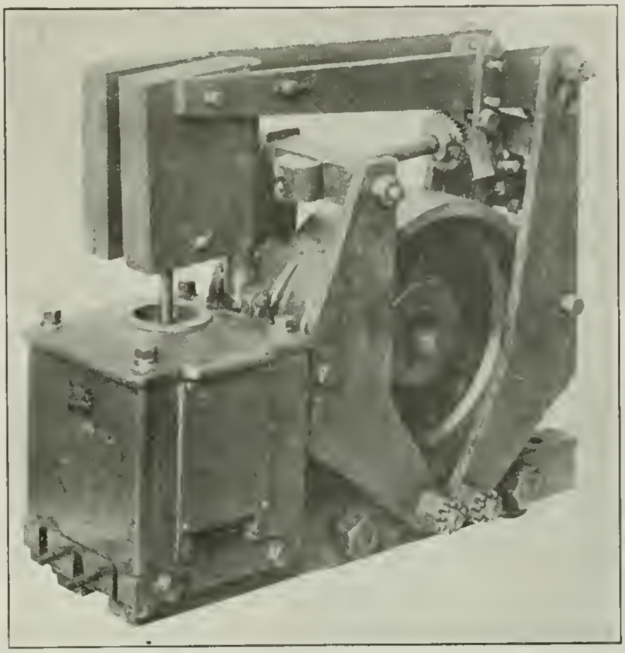


Fig. 2—Shoe type brake, gravity set and solenoid release.

On the other hand, there are many applications where the use of the shunt wound brake is necessary or preferable. In elevator service and mine hoist service the armature current may pass through zero and flow in either direction depending upon whether the motor hoists or retards. A series brake could not be held open. In the case of a crane hoist, the brake is ordinarily connected in series with the series field in lowering. If a high lowering speed is desired it is necessary to weaken the series field to a point such that the current passed in this circuit would not hold open a series brake. Shunt brakes are therefore frequently used for the hoists of coal and ore bridges, skull crackers and similar service. It is often desirable to have a drift point on a control. Obviously this is feasible with a shunt brake only as this may be maintained energized. Crane bridges are sometimes thus equipped, also lift bridges. The shunt brake also has some advantage in that its energizing circuit may be handled by a small contactor which may be interlocked with protective features. The advantage of the series brake lies in simplicity of action. The advantage of the shunt brake lies in flexibility of application.

The point has been raised that a shunt wound brake tends to be more sluggish than a series brake. This is due to the inductance of the shunt coil which retards the building up and dying out of the flux. In order to alleviate this condition some shunt coils, particularly for the larger brakes, are sometimes wound for half voltage and connected in series with resistance. This permits a high current inrush and gives quick release. In some cases the sluggish action is desirable. Compound wound brakes are not uncommon. The series coil is usually in circuit for a short period to give quick release. It is then short circuited by the control, having a comparatively light shunt winding to hold the brake released.

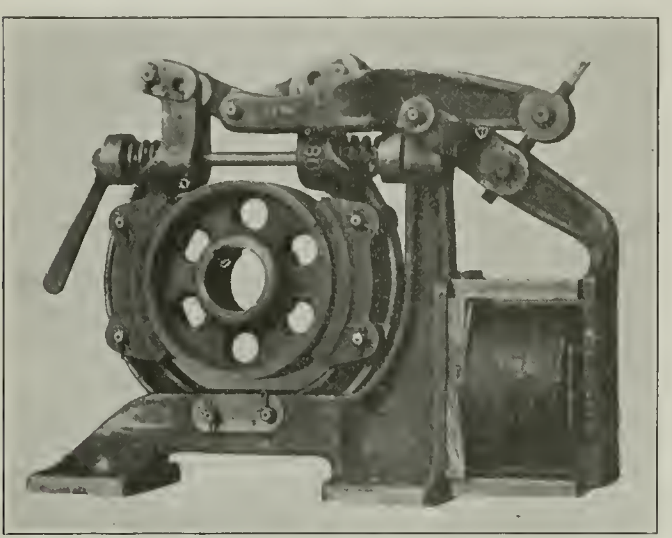


Fig. 3—Shoe type brake, spring set and magnet release.

The alternating current magnet is not as well adapted for brake duty as the direct current magnet. A relatively bulky laminated construction is necessary to limit iron losses and heating. The current in a single phase coil passes through zero every cycle. Shading coils are employed to carry the magnetism over these periods. However some tendency to chattering is liable. Some brakes are supplied with three phase coils, overcoming this difficulty. These however are relatively bulky and complex.

The solenoids for alternating current brakes are sometimes made oil immersed to minimize chattering and noise and also to act as a dash pot. This construction is particularly applicable for elevator service.

Alternating current brake solenoids are all shunt connected. The pull of the solenoid varies decidedly with the voltage. Taps are sometimes supplied so that the coil may be adapted to conditions. The current in a direct current coil depends on resistance and is independent of the air gap. The current in an alternating current coil is limited by impedance, mostly reactance. The longer the air gap the less the flux and the lower the reactance. The current is a minimum when the air gap is closed and is much higher when the gap is open. When voltage is applied a high current inrush occurs, the current falling off as the air gap closes. In operating an alternating current solenoid it is necessary to see that the moving core pulls up promptly, else the current will be excessive and will probably burn out the coil. As the gap is allowed to close entirely and seal, there is a possibility for this type of brake to hold open due to residual magnetism. Fig. 5 shows an alternating current shoe type brake in which a motor is employed instead of a solenoid for releasing. The brake is set by a spring. The motor drives through a pinion and toothed sector to which a lever is attached. The motor exerts torque to release and hold open the brake. The motor is a special high resistance cage type induction motor designed to withstand stalling. The motor is equipped with a combination slip gear and mechanical brake device which cushions its action. This type of brake is quiet in action as vibration and chattering are eliminated. The shoes are applied without shock and released without pounding. No dash pot is required. There is no initial current inrush and possible coil burnouts are avoided.

There are usually three adjustments to a solenoid or magnet operated brake. These are adjustment for shoe clearance, for braking intensity and for air gap. It is necessary to adjust the shoes for equal clearance and equal braking effect without side thrust. The braking intensity is adjusted by change in the amount or leverage of the weights, by changes in the lever linkage or by adjustment of the compression of the springs, as the case may be. It is desirable to maintain a definite air gap at the solenoid or magnet in order to obtain the required pull. The air gap should be the minimum amount which will give sufficient movement to release the wheel fully. The proper adjustment of the magnet, on direct current, affords the strongest obtainable magnet pull, thus permitting maximum braking intensity adjustment and giving prompt and definite action. In the case of alternating current proper adjustment helps to prevent excessive current inrush due to wide air gap.

It has been mentioned that some types of brakes are more sluggish in action than others. This is not always an undesirable feature. What is desired is prompt release without a hammer blow caused by sudden stoppage of the moving parts, together with prompt but gradual setting. Some brakes tend to grip suddenly and cause a shock to the load and the transmission gearing. It is evident that minimum inertia in the moving parts is desirable to these ends. In this respect the use of compression springs had advantage over weights. In some brakes either an air or oil dash pot is supplied to cushion the action, and

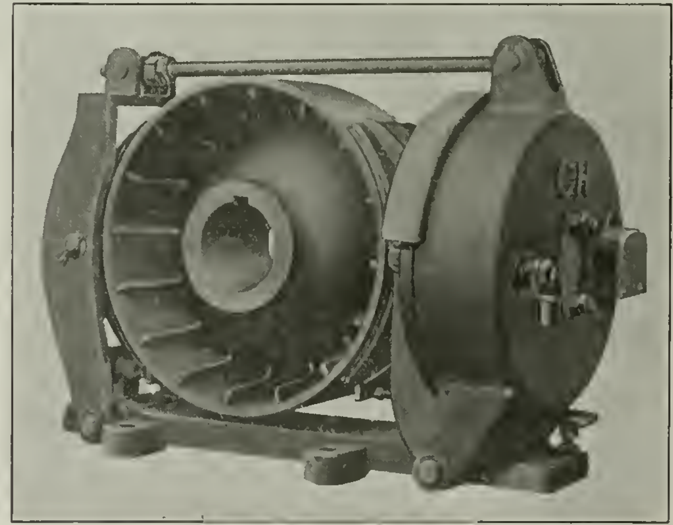


Fig. 4—Shoe type brake, spring set, magnet release.

prevent too sudden application. In a few cases, in connection with shunt wound brakes, electrical means are employed to delay the action. This may be done by shunting the brake coil with a discharge resistance. The stored energy in the coil causes a current to flow through the discharge resistance when the coil circuit is opened. This discharge current delays and cushions the setting of the brake. A short circuited damping winding will have a similar effect. Totally enclosed "ironclad" solenoids have this effect to a limited extent due to the eddy currents in the iron when the magnetism is established or interrupted. The motor released brake is damped to some extent by the inertia of the rotor of the small releasing motor.

Brakes are more commonly mounted separately on the motor bed plate. Frequently, however, they are attached to the motor. Motor mounted brakes require finished pads on the motor and, in some cases, special parts for adaption. Most crane and hoist motors are provided with brake pads. The advantage of motor mounting lies in the self contained unit with no alignment difficulties and no special base construction. The disadvantages are less firm and substantial construction and less easy dismantling. Motor mounted brakes are usually of the disc type.

Brakes are rated in lb. ft. of retarding torque which they will develop at the brake wheel shaft, as referred to revolving wheel condition. As the coefficient of static friction is higher, the holding torque is somewhat greater than the retarding torque. The holding torque is ordinarily about 110 per cent of the retarding torque. The retarding torque which a brake will develop depends materially upon the amount of weight or the extent to which it is "set up." This in turn depends upon the strength and ability of the solenoid or magnet to release. Where an intermittent duty coil is used, it may be worked harder and made more powerful. Therefore the brake may be set up tighter and its retarding torque rating increased.

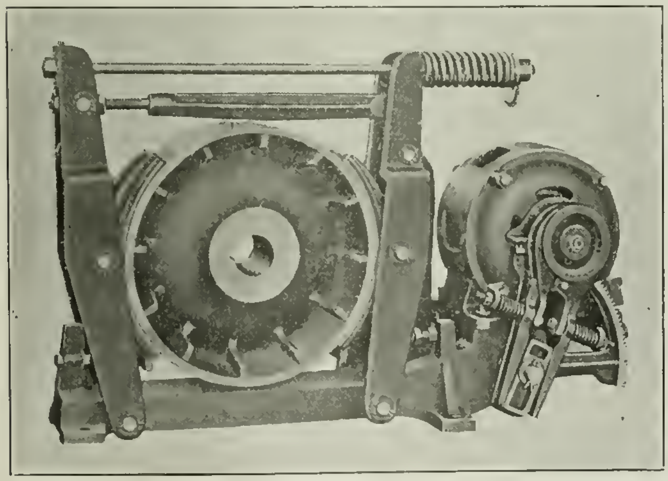


Fig. 5—Spring set, motor released brake for alternating current service.

It is evident that a brake retarding a given torque from high speed will dissipate more energy than one retarding the same torque at low speed. The ability of a brake to dissipate the mechanical energy which is converted into heat, is one of its limitations. Brakes are therefore given a maximum hp rating which signifies the highest hp motor with which the brake may be expected, under average conditions, to function without undue heating and with reasonable shoe wear.

The coil of a series brake carries motor current and must be proportioned accordingly. Brakes are rated in the same manner as the motors with which they are used, the common ratings being on a 30 minute or 60 minute basis for intermittent duty and a continuous duty rating. The intermittent duty brakes will release on 40 per cent rated current. Continuous duty brakes will release on 80 per cent rated current. Series brakes, once released will hold open down to about 10 per cent of rated current. It is desirable in crane hoist dynamic lowering that the brake release on 40 per cent full load current or less. The brake should open on the first point lowering.

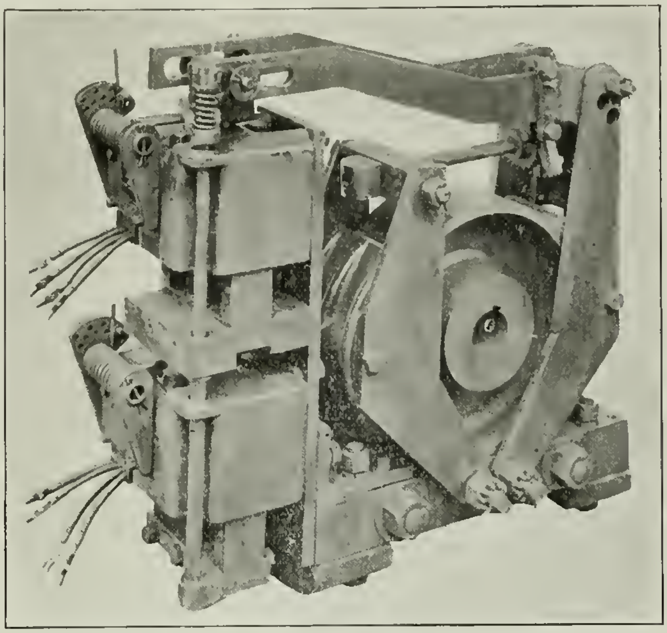


Fig. 6—Alternating current brake providing graduated braking effort.

Shunt wound brakes are given either a continuous duty or an intermittent duty rating. The coils of some brakes are wound for less than rated voltage. The coil is connected across the line to release the brake. Movement of the brake members actuates a small switch which causes resistance to be inserted in series with the brake coil. The reduced current is sufficient to hold the brake released but minimizes the coil heating.

Brakes are selected on the basis of torque. The full load torque of a motor may be determined by the formula—

$$T = \frac{5250 \times HP}{RPM}$$

Where T = torque in lb. ft.
HP = full load HP rating of motor.
RPM = speed of brake wheel.

Ordinarily a brake is selected having a retarding torque equal to full load motor torque. Sometimes a lesser torque will suffice and sometimes a higher torque, such as one and one-half times full load torque is thought desirable either to gain a very quick stop, to hold an occasional heavy load or to provide a safety factor, particularly as to adjustment and condition.

Where service is particularly severe or continuous the heat dissipating ability of the brake becomes a governing factor and it is necessary to select a brake on the basis of its limiting hp rating rather than its torque. The limiting temperature which lining materials will stand is about 200 degrees C. It may be well, at this point, to state that hard lining materials are desirable as they will retain adjustment better. Soft linings give more friction but they wear faster and compress.

For high speed work it is necessary to check the peripheral speed of the brake wheel.

The brakes which have been thus far described and discussed are of a type which are either fully set or fully released, as the case may be. There has been recently developed a brake for use on alternating currents which affords graduated braking. This brake is adapted for crane hoist service. It is similar in general construction to the ordinary shoe type solenoid brake. It has, however, two solenoids. One of these is connected across primary voltage and is energized only while hoisting and on the lowering points where regenerative braking is used. At standstill and on some lowering points this solenoid is deenergized. The second solenoid is connected across a phase of the rotor of the motor. When both solenoids are deenergized, as at standstill, full braking torque is obtained. In hoisting, the two solenoids function together to release the brake. In lowering, the second solenoid governs. When this solenoid is energized, the braking torque is relieved in proportion. As this solenoid is across rotor voltage, the higher the lowering speed, the less the slip and the lower the rotor voltage, hence the greater the braking torque. The brake thus automatically adapts its effort toward controlling the speed. Fig. 6 shows a brake of this type.

Electric brakes find a wide field of application. Cranes, hoists and elevators are probably the greatest field. Steel mill auxiliaries often require brakes. Lift bridges are so equipped. There are many miscellaneous applications.

In closing it may be stated in general as more desirable practice to retard and stop loads electrically by dynamic braking and to utilize the friction brake largely for holding. This practice minimizes the wear on the brakes, decreases their maintenance and insures with greater certainty their good condition for their important holding duty. There are, of course, many exceptions where this added complication may not be warranted.

Tropenas Converter For Making Steel

General Description of This Process, Details of the Converter and Information Regarding the Cupola Change—This Process Is Very Similar to the Bessemer Process.

By S. R. ROBINSON

THE original method of blowing steel was invented by Sir Henry Bessemer in 1856 in Sheffield, England. Bessemer thought that his patents covered every method of blowing steel, however, some years later Mr. Tropenas obtained a patent which covered the introduction of air onto the surface of the metal and supplemented this with an additional row of pipes or "tuyeres" which supplied additional air to convert any carbon monoxide (CO) to carbon dioxide (CO_2) that was not fully burnt by the lower row of tuyeres. The upper tuyeres were later discarded, having been found unnecessary.

By this process, there was less agitation of the bath, less power was required for blowing and the process was in every way better adapted for small heats from one to three tons.

The Tropenas process consists in melting a mixture of low phos. pig iron and steel scrap in an ordinary cupola, transferring this metal to a converter in which a blast of air is allowed to impinge onto the surface of the metal. The blast of air furnishes oxygen which unites with the silicon, manganese and carbon in the iron forming respectively Silica (SiO_2), manganese dioxide (MnO_2), and carbon monoxide (CO), and carbon dioxide (CO_2). Some iron is also oxidized forming F_2O_3. The silica, manganese oxide and iron oxide unite to form a slag consisting of silicates of iron and manganese, while the carbonic oxide goes off as a gas.

This reaction generates an intense heat which raises the temperature of the metal several hundred degrees and actually converts the iron into steel. When the "blow" is finished, which is indicated by the sudden dropping of the flame, we have a bath of metal containing about .08 per cent to .10 per cent C. and traces of manganese and silicon. The bath is then "recarbonized" by the addition of cold pig iron or more commonly a small amount of liquid cupola iron; the bath is then "deoxidized" by the addition of melted or lump ferro manganese (80 per cent Mn) and ferro silicon (50 per cent Si) so that the composition of the metal for soft or medium carbon steel shall be carbon .25 per cent to .30 per cent, manganese .60 per cent to .75 per cent, silicon .30 per cent to .35 per cent. A small amount of metallic aluminum is always added to the metal as a final deoxidizer—about 6 oz. to the ton. The metal is then poured into molds. By this process, there is no attempt made to lower the phosphorus and sulphur. It is an "acid" process, that is, the lining of the vessel is of an acid nature, namely, silica. Owing to this fact, the raw material must be as low as possible in phos. and sulphur. The low phosphorus pig iron should not contain over .04 per cent phos. or sulphur and the steel scrap if it is bought outside should be kept below .04 per cent in phos. and sulphur also if possible.

The Converter.

The writer will describe the vessel of 2 tons ca-

pacity, as he is more familiar with that size than the one ton vessel. The body of the converter is a cylindrical shell made up of boiler plate approximately ½-inch thick, riveted, with a cone shaped bottom also riveted to the shell, and a dome shaped top bolted or keyed to the top of shell. See attached sketch for inside dimensions. Some of the later vessels have a flat bottom, in halves, hinged, similar to a cupola. The bottom is dropped to allow the vessel to cool off quickly for repairs.

The "tuyeres" through which the air is admitted to the bath are of the utmost importance, for it is upon them that the entire operation depends. They should at all times be perfectly level and in line with each other and kept at the proper size. They can be made in three ways: first, special brick with a one and one-quarter inch diameter hole can be used. These brick are usually made of fire clay and are not very satisfactory. Second, ganister can be rammed around one and one-quarter inch pipe or rods and these pipe later withdrawn. This is the usual practice. Third, one and one-quarter inch inside diameter pipe can be rammed up in place and allowed to remain in the lining and used as "tuyeres." This method requires careful attention on the part of the operator, for if any hot metal lodges in the pipe, it is difficult to remove.

With proper attention, the latter method is the best. Seven tuyeres are used in the 2-ton converter. The converter is lined either with silica brick or rammed ganister. The best practice is to line with silica brick and patch with ganister. After lining, a coke fire is used to dry out the lining for about 24 hours. About two hours before the iron is ready to be poured into the converter, an oil burner is inserted through the central tuyere and the vessel heated with the oil flame supplemented with air from the positive pressure blower for more complete combustion. Before starting the oil flame, the converter is first emptied of all unburnt coke and ashes.

As soon as sufficient iron has been melted in the cupola, say 4,000 lbs., this iron is taken to the converter by the crane and poured into the converter. Just previous to this, the oil burner has been removed from the converter and the air shut off. As soon as all the iron has been poured into the converter, the operator or "blower" takes his station at the back of the converter and signals for the converter man to tip the vessel back. The blower puts on his blue glasses and looks through the tuyeres while the vessel is being slowly tipped back. As soon as the metal comes up to the bottom side of the tuyere hole, he stops the vessel. The metal should come almost but not quite in the tuyeres. The vessel should now be standing at an angle of from 6 to 10 degrees from the vertical—7 degrees is the best angle for blowing. If the angle is greater than that, some iron must be poured out of the converter; if the angle is less than six degrees, more iron must be put in the converter. The numbers of degrees is shown on a dial placed at the side of the converter. When the proper amount of iron has been put in the converter and the tuyeres are set correctly, the blast is turned on from the positive pressure blower. This blower should be of a proper size to deliver air at a pressure of from 2¾ lbs. to 3¼ lbs. to the square inch through the seven one and one-quarter inch tuyeres. This requires a No. 4 Root or Wilbraham-Green Blower.

This pressure of 3¾ lbs. to 3 lbs. is at once put on the converter. At once sparks and smoke are emitted from the mouth of the converter gradually increasing in volume until at the end of from 3 to 5 minutes a flame shows at the mouth of the vessel. This flame gradually increases in intensity until at the end of from 10 to 12 minutes from the start of the blow the "boil" commences, at which time the pressure must be reduced in order to prevent metal from being thrown out of the vessel. The "boil" continues for from one to three minutes the flame increases in size and the air pressure is again increased to about 2¾ lbs. The blowing is continued for about 8 minutes when the flame again increases in size but with less tendency for the metal to be thrown out of the vessel. The flame after about one minute suddenly "drops" or becomes shorter by one-third which marks the end of the blow. The converter is then "turned down" as rapidly as possible and the air shut off. The bath is now ready for the deoxidizers. The ferro manganese may be added cold in lump form by wetting the lumps and throwing them into the bath or this alloy may be broken up into small pieces and thrown into the ladle while the metal is running in, or the alloy may be ground fine and preheated in the ladle and the metal poured onto it. The ferro silicon using the 50 per cent alloy is put in the ladle. Aluminum is also added. Points to be watched in blowing:

As soon as the carbon flame shows, the vessel must be tipped back toward the vertical about 2 degrees. The first stage of the blow from the time the air is put on until the carbon flame shows, is the period of great importance. During this time, the silicon is being burnt or oxidized from silicon to silica (Si plus O_2 equals $S{:}O_2$), and also the manganese and some iron, but these are of less importance, as heat producers than the silicon. Bear this point always in mind: **The silicon is the heat producer in the converter process.**

If the melted iron from the cupola is deficient in silicon, regardless of the temperature of this iron, the blow will come cold unless additional silicon is added during the blow. The silicon content of the cupola iron should be about 1.8 per cent. The first period of the blow should last from 3 to 5 minutes. If less than 3 minutes, additional silicon should be added at once by throwing into the converter lump 50 per cent ferro silicon usually about 20 pounds.

If the first period is longer than five minutes, the silicon is too high and a "sloppy" "wild" blow will usually result. This can be corrected in subsequent blows by lowering the silicon in the charge. The length of the first period is, of course, dependent on the proper setting of the tuyeres. As a rule, before starting to set the tuyeres, the vessel should be turned down to a horizontal position and the metal thoroughly skimmed. Then set the vessel so that the metal shows just at the under side of the tuyeres. If this is done properly, the above remarks in regard to the length of time of the first period will hold good.

The Cupola Charge.

The charge is made up of low phosphur pig iron and steel scrap, from 30 per cent to 50 per cent steel scrap is used. The charge is figured so that the silicon in the melted iron will be 1.80 per cent Si. allowing .25 per cent loss of silicon in melting. Thus: Suppose the pig iron contains 3.25 per cent silicon and the steel scrap .25 per cent silicon, then a charge of 1,000 lbs. of the mixture will contain 600 lbs. pig iron and 400 lbs. steel scrap. 600×3.25 equals 19.5 lbs. silicon.

400×.25 equals 1.0 lbs. silicon.

Total 20.5 lbs. silicon.

Then 20.5 × 100 equals 2.05 per cent silicon going into cupola. Allowing .25 per cent loss, we have 2.05 — .25 equals 1.80 per cent silicon coming out of cupola.

Final additions:

Ferro manganese if used in the ladle.

It will require about 20 lbs. of the 80 per cent alloy to the ton to give .70 per cent Mn in the steel.

It will require about 12 lbs. to the ton of 50 per cent ferro silicon to give .30 per cent silicon in the steel.

Costs:

Assuming low phos. pig at	$40.00	ton
Own steel scrap	35.00	ton
Outside steel scrap	12.00	ton
Ferro manganese	60.00	ton
Ferro silicon	60.00	ton
Coke	6.00	ton

Assume charge of 60 per cent pig iron and 40 per cent steel scrap. Assume a combined cupola and converter melting loss of 18 per cent.

Then:

Cost of 1,200 lbs. pig iron equals	$21.43
Cost of 800 lbs. steel scrap equals	9.40
Total	$30.83
Allowing 18 per cent loss, cost per ton	$36.38
Cost of 20 lbs. ferro manganese equals	.60
Cost of 12 lbs. ferro silicon equals	.36
Cost of 300 lbs. coke	.90
Cost of repairs	1.00
Cost per ton steel in ladle exclusive labor	$39 24

Breakage of Rolls on Sheet and Tin Mills

A General Discussion on the Characteristics of Sheet and Tin Mill Rolls Showing the Causes for Breakage and How to Avoid Them.

By W. H. MELANEY

PART I

A GREAT deal of mystery has always been associated with the breakage of rolls on Sheet and Tin Mills and very few mill managers attribute it to exactly the same cause.

All of them will agree that heat is the most prolific source of the trouble, but few of them ever try to reason out why this is true, and fewer still seem to realize the small amount of heat that is required to produce disastrous results under certain conditions.

In order to get a clear understanding of conditions, it will be necessary to first consider the composition of and method of casting these rolls, and the radical difference in structure between the rolling surface of the roll and the mass of metal that composes its interior and just what happens when these two very different structures are suddenly heated.

It is true of course, that the chemical composition of both structures are approximately the same, as they are both poured from the same ladle of metal. But due to the conditions under which they are cooled down to the temperature at which the metal sets or assumes the non-fluid state, there will necessarily be a slight difference in the proportions of the various elements that go to make up the whole mass, especially in the carbons.

Casting a Chilled Roll.

All chilled rolls are cast in an upright position. The mold being of a composite structure, as shown at (Fig. 1), in which the rolling surface of the roll is cast in a heavy cast iron mold, and the necks and wabblers in sand.

Characteristics of Chill Irons.

It is a characteristic of cast iron of the composition of which chilled rolls are made, that if it is suddenly cooled from its molten state below the temperature at which it sets or becomes a solid mass, that the portion so cooled will assume a crystalline form.

This is due to the carbon which is all believed to be in the combined form when iron is in a molten state. If there is no element in excess, such as silicon or manganese, to force it out of combination in cooling by permitting it to change from combined or crystalline carbon, to that of graphitic carbon, then when the molten iron is suddenly cooled, the carbon will practically all remain in the combined or crystalline form. Therefore, in casting a chilled roll, that portion of the mass that can be so suddenly cooled will retain its crystalline form and become a solid white mass, as hard as hardened steel with its crystals at right angles to the chilling surface, while the metal contiguous to it for a certain depth, will be of a speckeled or sprayed appearance, partly crystalline and partly granular, as a part of its carbon, due to slower cooling, will precipitate out into the form of graphitic carbon, thus causing this sprayed appearance.

This sprayed portion will, in an ideal mixture, be approximately of the same depth as the white hard crystalline portion, while all of the rest of the mass of metal down to the center of the roll, will be ganular. The still slower cooling permitting most of its carbon to assume the graphitic form and as graphite is almost black in color, this part of the roll will be of a dark gray color, in sharp contrast to the white chilled portion or the light gray sprayed portion. The white crystalline portion known as the chill on sheet or tin mill rolls, will vary from ½ in. to ¾ in. deep. The longer rolls having the lighter depth of chill.

Form of Mold.

(Fig. 1) is a sectional view of a mold, such as a chilled roll is cast in.

The lower portion "A" consisting of an iron flask rammed with molding sand which contains the lower neck and wabbler of the roll. The middle portion "B" is a thick cast iron cylinder, bored out to suit the diameter of rolls wanted and in which the body of the roll is cast. The top portion "C" also an iron flask rammed with sand and containing the top neck and wabbler, as well as the sinking head.

The sinking head is used to prevent piping or hollowness in the top wabbler, by feeding liquid metal to this portion as the roll slowly cools, and is later cut off when the roll is turned to size.

When this mold is filled with molten cast iron of the proper chemical composition, that portion in contact with the iron cylinder "B" is rapidly cooled as iron being a good conductor of heat, absorbs and radiates the heat of the molten metal in contact with it until its setting point is reached, and which only requires a few seconds.

The result is a crystalline mass of white hard chill of a given depth, depending upon the chemical composition of the mixture.

The sprayed portion being due to the tapering off of the cooling action as this metal is out of contact with the chilling action of the cylinder "B"

The dark gray mass beyond the sprayed portion being still further away from the chilling action, is permitted to cool gradually thus permitting the bulk of the carbon to assume the graphitic form and produce a granular structure. The molten metal in those portions of the mold which are rammed up with sand, due to sand being a very poor conductor of heat, cools so slowly that even the surface shows no crystalline nature and is all of a dark comparatively soft granular structure, the same as the center of the roll.

Physical Characteristics of the Roll.

A little reasoning will prove to you that here you have a composite structure in the resulting roll showing at least three clearly defined physical characteristics.

A white hard portion, say ¾ in. deep with a total shrinkage of ¼ in. to the foot and which expands rapidly on heating.

A sprayed portion of approximately the same depth with a slower rate of shrinkage approximately 3/16 in. to the foot and expanding slower than the white hard portion. And a dark gray mass in all the rest of the roll of a granular structure with only ⅛ in. contraction to the foot, and having a still slower rate of expansion on being heated. All three of these characteristics being assembled in one inseparable heterogeneous mass.

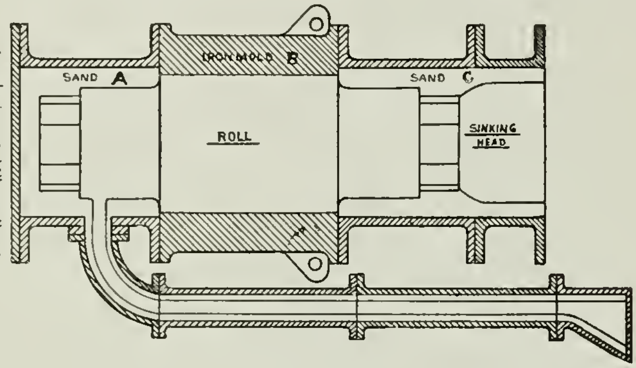
It requires very little thought to convince yourself that if the outer surface of the roll with a contraction practically double that of the inside mass did not get most of its contraction while the inside was still fluid, that it would tear itself apart in cooling, during the casting process, and this sometimes happens.

Also that the casting strains would wreck it but this is taken care of by prolonging the final cooling of the roll over a long period of time to permit the molecules to gradually re-arrange themselves.

The chilled surface due to contraction soon gets out of contact with its iron mold, which also due to the absorbtion of heat rapidly expands and increases the distance between it and the chilled surface of the roll with the result that this chilled portion is gradually raised in temperature, by the molten metal of the interior, permitting a certain amount of annealing action to take place, thus relieving the casting strain.

Preparing the Rolls for Rolling Sheets.

After the rolls have been turned they are placed in the mill housings preparatory to rolling sheets. Finishing rolls of this type are of necessity used hot and a final working temperature of 750 degrees F. has been found to give the best results in practice, but if this temperature was permitted to extend into the necks, it would be found impossible to keep the necks lubricated, as the lubricating grease would catch fire and burn up, leaving the necks dry. Therefore, a small amount of water is permitted to trickle over the neck or wabbler to absorb a part of this heat and keep the necks cool enough for proper lubrication but no water is permitted to touch the rolling surface of the roll. The temperature of the ends of the roll being regulated by the water on the necks.



Sectional view of chilled roll mold

Fig. 1.

Concaving Rolls.

The center of the rolling face of a roll is always the hottest point when in service, due to the ends of the rolls having a portion of their heat radiated out through the necks and wabblers. The center of the rolls being almost twice as hot as the ends.

This causes the center of the rolls to puff up and the surface would become convex if some means were not employed to prevent it. A perfectly flat surface or one in which the surface of the rolls are in contact over the entire working face, is desired, as under these conditions only can wide sheets be rolled.

This condition is easiest produced by turning in the face of either one or both rolls a concavity equal to the amount of convexity that would otherwise result.

When the rolls are at proper working temperature, this concavity disappears, due to the puffing up of the center of the rolls from expansion by heat. The trick being to keep this puffing up under complete control so that it is neither too great nor too little to give the rolls an even bearing along their rolling face.

The usual method of control being the blowing of air or steam upon the center of the rolls to regulate the expansion, as even the temperature of dry steam is much below the working temperature of the rolls and will rapidly reduce their heat, thus preventing their puffing up too much in the center.

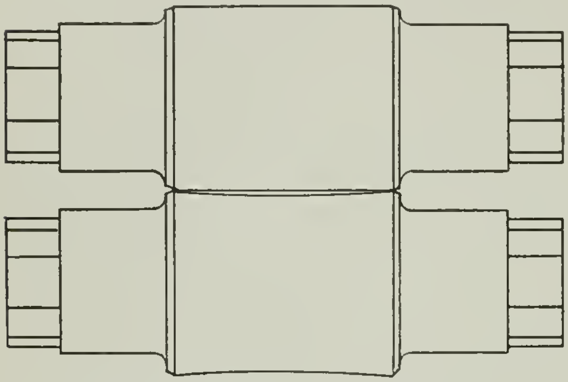
Heating the Rolls for Service.

As rolls when first placed in service are of a temperature corresponding to that of the surrounding air, it is evident that due to the concavity previously turned in them, they would only be in contact on each end of the roll, see (Fig. 2), and as this condition would prohibit the rolling of sheets of even gauge over their entire width, it becomes necessarv to first heat the rolls in order to puff up the middle until this concavity disappears, (see Fig. 3), before wide sheets can be rolled on them.

Causes of Breakage.

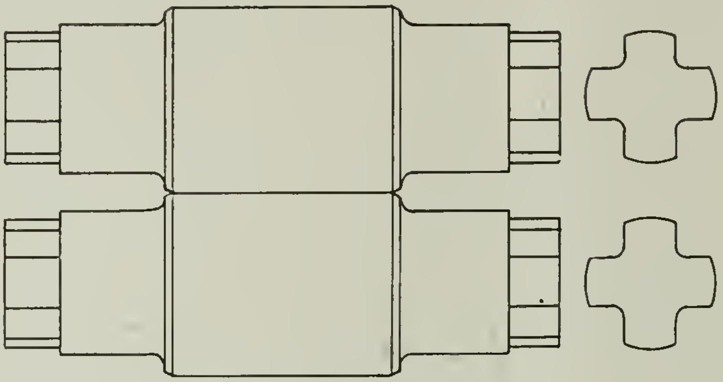
Right here is where all the trouble starts as very few of the operatives seem to realize the extreme sensitiveness of these rolls to heat conditions, and what is really taking place during this warming up process, or how little heat is sufficient when quickly applied, to tear the rolls apart.

A roll can be broken with a temperature scarcely too hot to bear the hand on if it is applied quick enough, and the following conditions are believed by the writer, to be the most prolific source of trouble.



Showing concave in rolls before heating

Fig. 2.



Same rolls heated to working temperature

Fig. 3.

1st. The chilled surface of the roll as previously stated has an expansion approximately twice that of the gray granular interior.

2nd. Under all the present day processes of warming up, this chilled surface of the roll is the first part to be heated, thus accentuating an already precarious condition, as the chilled surface must of necessity become quite hot before the gray metal behind it is even warm. This is conclusively shown when rolls sometimes break before a half dozen bars have been rolled on them and when the heat in the roll is not sufficient to even discolor the fracture and in deep chilled rolls many are broken simply by the warming up and before even a bar has been rolled on them.

3rd. Many seemingly perfect rolls are broken during the warming up process when there is no pack in the mill. This is caused by the surface of the roll becoming heated so rapidly that the interior of the roll did not get warm enough to expand the slight amount its preponderating mass would require, to take care of the very rapid expansion of the face or chilled portion, and the roll is torn in two.

4th. It is a known fact that most of the roll breakage occurs in the fore part of the week before the rolls have reached their final working temperature, also there is more breakage in the extremely cold winter months than in the summer time, due to the lower temperature at which the warming up starts and it is the writer's opinion that no matter when the roll actually lets go the condition that finally put it out of commission was started on the warming up turn.

5th. That it is a heat condition rather than a torsion or bending stress that breaks these rolls, is self-evident when you consider that the wabbler of a roll on the leading mill, with only one-third the area of the body of the roll must transmit all of the torsional stress of all the mills on that side of the drive. Yet few wabblers are broken off in comparison to the number of rolls that are broken through the body although the body only carries its individual load.

6th. That the remedy for roll breakage is a better and slower means of warming them up until they reach the proper rolling temperature, which is assumed to be that which will produce a bright blue color on the chilled surface of the roll.

7th. While it is unquestionably true that when a roll is subjected to excessive torsional and bending stresses at the same time the rapid expansion of its face is taking place, the danger of breakage is greatly increased, the primary and most responsible cause of breakage is the too rapid heating of the face of the roll by heat applied solely from the outside through this crystalline face before the center of the roll has even had a chance to become warm.

8th. The gagging of rolls due to excessive screw or poor top neck lubrication, will result later on in both rolls breaking as the sticking of the hot bar between the rolls causes an excessive heating of this one spot on the rolls circumference, starting a fracture in the chilled face of the roll that either causes it to spawl or break later on and it can be safely figured that every time a gag occurs that it means shorter life for that pair of rolls.

9th. A broken coupling box or spindle which is not considered by the average operative as an abuse of the rolls because it is more or less beyond his control may be much worse than a gagged roll because under this condition perhaps several stands of rolls are stopped with the hot bars between them.

10th. Last but by no means least is permitting the temperature of the rolls to vary greatly up or down by irregular operation of the mill.

Acid Open Hearth Process for Manufacture of Gun Steel and Fine Steel

Detailed Description of This Manner of Work, Giving the Various Steps of Manufacture—Result of Investigations Made by Special Committee as to Difficulties Encountered.

By W. P. BARBA and HENRY M. HOWE

PART III

51. **Prevention of Transverse Cracks by Giving the Crust of the Ingot Firm Salient Ties.**—(a) The ingot may be torn transversely, not only by the resistance of the slower cooling, deeper seated layers to its longitudinal contraction, but also by any other impediment to that contraction, for instance by its being caught at its top by a fin, or by some roughness in the mold. In this case the weight of the part of the ingot below the obstruction may suffice to cause transverse cracks, especially because its effect is always aggrevated by the resistance of the slower cooling, deeper seated layers to the faster longitudinal contraction of the skin. Mechanical attachment of the upper part of the ingot to the mold is more likely to occur when the large end of the ingot is uppermost. The obstruction to longitudinal contraction is, of course, all the worse if the ingot is caught at both ends by the mold.

(b) In order to prevent this transverse cracking by excessive longitudinal stress, the ingot should be provided with saliences which, by outrunning the cooling of the non-salient parts, become in fact more or less firm ties. The four main edges of a square ingot are such saliences, which thus become longitudinal ties, and by their integral union with the metal of the faces of the square tend to prevent it from being torn transversely by the longitudinal stress.

52. **Octagonal and Square Molds.**—(a) The chief advantage of an octagon is that it has twice as many of these supporting edges to act as longitudinal ties, and prevent the faces between from being torn across by any resistance to the longitudinal contraction of the ingot.

(b) It might at first be thought that, if increasing the number of faces from four in a square to eight in an octagon is an advantage, we should get a further advantage by still further increasing them to twelve or even more. In some works ingots with as many as twelve edges are made. But if we push this too far we fail to accomplish what we seek. If the number of edges were infinite, the ingot would be a cylinder. It would in the first place have the most unaccommodating shape possible, and in the second place would have no ties for preventing the cracking of the faces. The more edges there are, the less can each edge project beyond the faces between which it lies, without running the risk of cracking in cooling, and of folding in forging, and the less therefore can it outrun the cooling of the faces and the less support can it give them.

(c) The purpose of making the faces of the octagon concave is to give its eight edges greater salience, so as to increase the degree to which they outrun the cooling of the faces between them, and thus to increase the support which they offer them.

(d) The square has the further disadvantage when compared with the octagon that its corners in cooling tend to outrun the intermediate faces so greatly that a sort of St. Andrew's cross, or plane of weakness running diagonally from corner to corner of the square, forms readily. It is the junction of columnar crystals out from the adjoining faces.

This tendency should be lessened, first by making the mold much thinner at the corners than at the faces of the square, and second by rounding the corners. Yet this rounding should leave them as sharp as is compatible with their not crusting during pouring, and with their not forming these diagonal planes of weakness, because to dull them brings the periphery toward the cylindrical form, and thus lessens its power of accommodating itself to the resistance of the slower cooling interior. In general, the radius of the faces is about half the diameter of the ingot.

TABLE 1.—DIMENSIONS OF INGOT MOLDS

Nominal Size.	18 In. Sq.	26 In. Oct.	35 In. Oct.	40 In. Oct.	45 In. Oct.
Radii, in in.:					
of edges ..		1.50	1.50	1.50	1.25
of fluting .		14.875	20.00	20.00	28.00
Taper, inches, of diameter per foot of height	0.3985	0.4220	0.4232	0.4305	0.4148
Height, in...	60.25	87.312	76.062	78.375	76.75
Ratio height to nominal diameter ..	3.35:1	3.36:1	2.17:1	1.96:1	1.71:1
Ratio, thickness of ingot to thickness of wall at top	5.38:1	4.29:1	4.21:1	4.46:1	4.57:1
At bottom.	2.30:1	2.63:1	3.17:1	3.18:1	3.81:1

Square ingots may well have concave sides between the corners of the square, if they are to be bloomed, so that they may ride more easily, and be the more easily guided, on the feeding table of the blooming mill; whereas they are frequently made convex when the ingot is to be forged. In an octagonal ingot, the faces should have the shortest radius, and the edges the greatest salience, which will not lead to the formation of folds in forging.

(e) An additional reason for not making the vertical edges of either the square or the octagonal mold too strongly salient, is that the salience, if too strong, would outrun the rest of the ingot in heating for forging so greatly as to be in danger of being burned. There are other limiting considerations which could be discussed, were it not for burdening this paper with too much detail.

53. **Examples of Molds.**—Table I gives the dimensions of ingot molds of five different sizes from very good practice. The molds would probably be improved by thinning their walls at the top and thickening them at the base. The tapering of the mold walls has been carried out successfully ever since 1897 in making fine steels.

One steel maker advises that, for ingots about 24 in. in diameter, the ratio of the cross-section of the mold to that of the ingot should be two to one at the bottom and a little more than one to two at the top, though this may make the mold too fragile at the top for rough work. On the other hand for ingots more than 24 in. in diameter, the two to one ratio would give the bottom of the mold a clumsiness that would hardly be compensated for by the extra heat which it would absorb from the ingot bottom. Hence this ratio should decrease as the diameter of the ingot increases beyond 24 inches.

54. **Hot Top and Discard.**—(a) The ratio of the steel in the hot top to that in the ingot proper should, in general, be from 15 to 25 per cent. according to the specifications as to top discard. For instance, for gun steels the Government requires 30 per cent. top discard. It is convenient and wise to let 25 of this 30 per cent be made up by the steel contained in a sand-lined sink head, and the remaining 5 per cent by the few inches of the top of the ingot proper which could not be used for gun steel in any event, because they form the joint between the ingot and the skin head.

(b) The purpose of the discard is to remove any mechanically unsound parts, and any that are unduly enriched in phosphorus and sulfur by segregation. With the use of a hot top, and with well-made steel carefully poured, there is much less than 30 per cent of the ingot that is subject to mechanical unsoundness. Moreover with well-made, thoroughly deoxidized steels very free from phosphorus and sulphur, such as can be made in the electric furnace, the content of phosphorus and of sulphur cannot become harmfully great even at the local enrichment at the ingot top. Hence it is expected that this 30 per cent top discard will be reduced to 20 per cent, or even less in special cases. This would be wholly justified.

(c) The use of sink heads of sand in top pouring is open to the objection that the stream of very hot steel, running down in the neighborhood of the sand, is apt to heat it so suddenly and so highly that it disintegrates, so that enough of it runs down into the mold to add appreciably to the inclusions.

(d) The use of carbonaceous material in the sink head implies a certain danger that the carbon may be taken up by the upper layers of steel, and may be carried down to a very considerable depth, partly by diffusion and partly by convection. Sulphur prints of ingots have shown clearly, what was indeed evident on careful consideration, that there is a very great degree of sagging down or sinking down along the axis of the ingot.

55. **Top and Bottom Pouring.** — Bottom pouring has the advantages:

(a) That in it the upper surface of the molten metal is visible throughout the operation, for the guidance of the pourer, whereas during the early part of top pouring from a bottom-poured ladle the ladle itself cuts off our view of the surface of the ingot. This disadvantage of top pouring may sometimes be avoided by pouring from a lip, or through a head box.

(b) That the surface is not disturbed, as in top pouring, by the impact of a falling stream of metal, and hence that its indications are more decisive, more easily interpreted.

Both these advantages are of less weight for very wide ingots than for those of intermediate size, because the surface of the former becomes fully visible earlier, and is less disturbed by a descending top poured stream than that of the latter.

(c) That it permits group pouring, leading to great uniformity of conditions among the ingots of a given lot.

(d) That during all but the latter part of the pouring, the rapid uprush of the stream along the axis of the mass tends to lessen the quantity of heat which it transfers to the lower part of the ingot, and to increase correspondingly that which it gives to the ingot top, thus lessening the tendency to pipe. This effect of bottom pouring is favored by the shape which the inner surface of the walls of the ingot assumes, that of an inverted cone. This merit of bottom pouring increases with the velocity of the uprising stream, and hence increases with the size of the ingot, and decreases as the pouring progresses.

(e) That it avoids cutting the bottom of the mold by the impact of the falling stream of metal, as occurs in top pouring of long ingots.

On the other hand bottom pouring is at a disadvantage:

(f) In needing more complicated molds, more expensive to place.

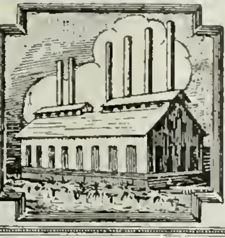
(g) In scrapping some of the metal in the form of runners, etc.

(h) In its liability to befoul the steel with matter cut or fluxed from the runner bricks.

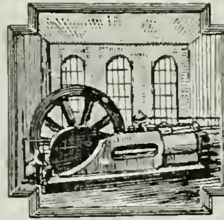
(i) In increasing the danger of "run-outs" by its keeping the metal in the runners molten.

(j) In giving up to the bottom of the ingot an undue proportion of the heat of the last of the fresh hot steel added, thus increasing the tendency to pipe. This is because, during the last of the pouring, the rise of the incoming steel along the axis of the ingot is necessarily slow, both because now the level of the steel in the mold can be but little below that in the runner, and because the steel must now be added cautiously and hence slowly in order that the ingot may be given the predetermined height accurately. In top pouring, on the other hand, the last of the hot steel is added directly and slowly to the top of the ingot to which most of its heat is transferred, very little reaching the lower part of the mass.

This advantage of top pouring probably outweighs the corresponding advantage (d) of bottom pouring, both because the upward concentration of heat by (d) does not apply to the uppermost part of the ingot, the part which has the greatest effect on the piping tendency.



STEAM POWER DEPARTMENT



The Field of the Large Boiler

Some Interesting Data on the Large Boilers Installed at the River Rouge Plant of the Ford Motor Company—Charts Showing the Boiler Efficiency.

By J. B. CRANE

We can all remember when the first large turbine units were installed how the majority of the engineers said the field would be limited, that it was much better to have a large number of small units, so that if anything happened to one unit, only a small percentage of the total power apparatus would be shut down.

The history of the first large turbines tended to strengthen the stand of these engineers, as considerable trouble developed with the turbines on account of the difficulty in securing materials that would stand up under the stresses imposed and which were not thoroughly understood at that time.

However, today no one hesitates about installing large turbines, generators and transformers, if the load conditions warrant it.

In other words, the large turbine with its multitude of blading, piping, valves, generator and exciter, condenser and auxiliaries, wiring and switches, has proved its reliability.

If two to four boilers are considered sufficient to supply steam for a 5,000 or 10,000 kw. turbine, it should not require more than this number of boilers for a 20,000 or 40,000 kw. turbine, and when it is realized how much less apparatus there is to get out of order with a boiler and its auxiliaries than with a turbine and its accompanying apparatus, there must be something wrong with boiler designers if they fail to deliver the goods.

The first large boilers (2365 hp.) were installed at the Delray plant of the Detroit Edison Company, and their operation was so successful that when the Connors Creek plant was built by the same company in 1914, boilers of the same capacity were installed with the intention that two boilers would supply steam for one 25,000-kw. turbine, when the boilers were operating at 170 per cent of rating. No spare units were installed, and experience has shown that two turbines can be safely and economically operated with three boilers at 225 per cent rating.

Boilers of 2500 hp. capacity were installed by the Ford Motor Company at their Highland Park plant, but this rating included pre-heaters, which it was subsequently necessary to abandon on account of corrosion troubles.

At the River Rouge plant of the Ford Motor Company Ladd 2647-hp. boilers were installed in 1920, and these have now been in operation long enough so that some of the operating results are of interest.

Boiler No. 1 was put in service November 12, 1920, and operated continuously under loads varying from rating to 300 per cent for 140 days, when it was first shut down for purpose of inspection. After six days the boiler was again put on the line and ran for 133 days under the same loads as above. The second shut-down was for the purpose of inspection, cleaning accumulated ash from boiler setting walls and replacement of a leaky superheater unit.

It was again started September 29, was still running on March 1, a period of 183 days, and the initial efficiency was being maintained.

The other three boilers show similarly good operating records; there have been two boiler tubes lost on the four boilers in 15 months, and these were removed during periods of inspection, due to the presence of small blisters which it was feared might later cause trouble.

A very careful examination of the setting was made on No. 4 boiler after a year's operation, and it was the opinion of the engineers making the inspection that there would be no serious trouble with the brickwork for several years.

Apparatus is being assembled to run complete tests on these boilers, but in the meantime it may be interesting to observe the following figures which are obtained in daily operating practice, as shown by the weights of coal taken daily, and output, by integrating the curves of the steam flow charts:

Load	Flue Gas Temp. F.	CO_2%	Estimated Efficiency	Draft Loss: Inches of Water
100	455	15	82.8%	0.25
200	490	15.6	82.7	0.50
300	560	15.0	80.2	1.0
400	670	14.8	74.0	2.0

These boilers have no economizers and the above efficiencies show per cent of heat absorbed by boiler and superheater on basis of gross heating value of coal.

Tests for moisture in steam from boiler showed 1.2 per cent at 300 per cent rating and less than 1 per cent at 200 per cent rating.

Another interesting feature of the installation at the River Rouge plant is that these are the first boilers to use blast furnace gas and powdered coal in combination.

Enough blast furnace gas is furnished to carry 1900 to 2000 hp. on each boiler, and powdered coal is used to furnish deficiencies, and loads in excess of that that can be carried by blast furnace gas. The powdered coal equipment and blast furnace gas burners were furnished by the Combustion Engineering Company, and the operation is highly satisfactory. There are no driers and while the coal ordinarily contains 5 to 6 per cent moisture, coal containing 12 per cent moisture has been burned.

The superheaters are Elesco, made by the Superheater Company, and it is interesting to know that the total steam temperature as delivered from the superheater varies less than 10 per cent with a variation of load from 150 to 400 per cent of rating.

The accompanying charts show the type of load on these boilers and one of the big advantages is the speed with which loads can be increased and decreased almost instantaneously.

The cost per horsepower for boilers alone for two 3,000 against four 1500 or six 1000 hp. boilers will be very nearly the same, but the largest boilers will require less floor space, less excavation, less foundations, less steel work, less building, less roof, less valves, less piping, less brick in the setting; and the final cost installed will be less than for the greater number of smaller boilers; and as there will be less furnace wall about the boilers the loss by radiation will be less; and consequently, all other things being equal, the efficiency will be higher, there will be less labor required to operate the boilers, and these operators will have less apparatus to watch and can give it very much better attention, so that both the thermal and economic efficiency will be higher.

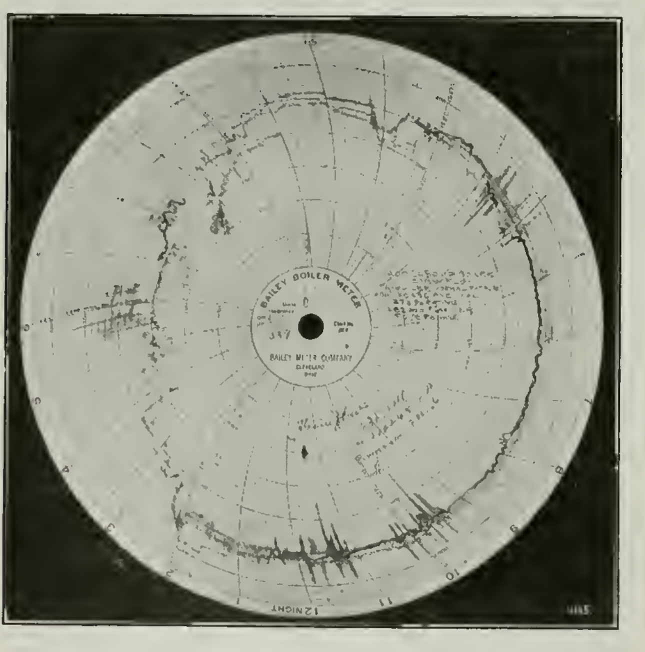


Fig. 1—Chart showing operation of boilers in Ford plant.

Boilers up to 9000 hp. normal rating can be built with materials now available, and the stresses will be no greater than that prevailing on this installation.

There is considerably more flexibility than exists on the turbine end of the plant, where a turbo-generator will carry its rated capacity and no more.

The flexibility, when proper methods of fuel burning are used, is so great that it is safe for engineers to figure on two boilers to carry their entire load at 190 to 200 per cent of rating, and in emergencies one boiler will carry the entire load at 380 to 400 per cent of rating.

Consideration must also be given to the character of the load, for it would of course be manifestly unwise to install two boilers to operate a load that only lasts for a short period of each year, when the load for the remainder of the year is very much less; and under these conditions the proper number of boilers should be installed to take care of the minimum as well as the maximum conditions.

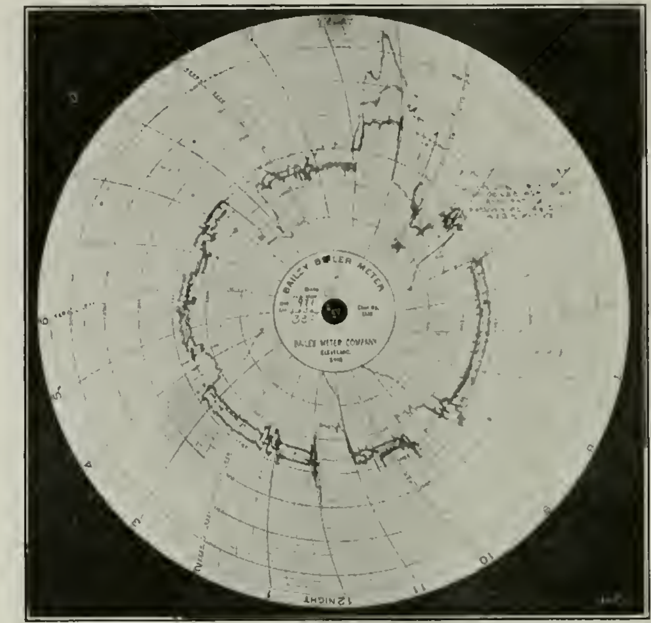


Fig. 2—Chart showing operation of boilers in Ford plant.

LETTER TO THE EDITOR

Dear Sir:

We have read over our article entitle entitled "Air Required for Combustion of Gases" which appeared in Blast Furnace and Steel Plant March, 1922, pages 174-175.

We find a different constant in the formula gives values, especially in the lower part of the curve, much nearer the actual data.

The exact formula should be:

Cubic feet of air theoretically needed per cubic foot

$$\text{of gas} = \frac{9.67 \text{ Btu.}}{1000} - .25$$

and the approximate formula should be:

Cubic feet of air theoretically needed per cubic foot

$$\text{of gas} = \frac{\text{Btu.}}{1000} - .25$$

We regret that this error was not discovered before submitting the article and trust that its rectification will cause no inconvenience.

Very truly yours,

A. F. Spiehler.

Reduction of Fuel Wastes in the Steel Industry

By **F. G. CUTLER**, Ensley, Ala.

The paper sets forth the economy of utilizing blast furnace gas, at one time considered to be of little material value, in reducing the wastes of the steel industry. It is shown how the quantity of gas to be expected in the production of one ton of pig iron may be computed, and the uses to which this gas may be put are analyzed quantitatively. A heat balance, based on the production of one ton of pig iron, is presented, showing the sources of heat and the requirements for blast furnace and steel mill operation. It shows that the total heat from the by-products of a ton of pig iron is more than sufficient to finish a ton of steel. The heating requirements are not met by the tar and by-product gas, although the average power requirements are more than met by the blast furnace gas and coke breeze. It therefore becomes desirable to reduce the heating requirements for the production of steel by using more efficient heating furnaces, and to conserve all possible heat by charging hot steel into the soaking pit and reheating furnaces, in order to reduce the quantity of fuel required for supplementary heating.

IN this period of readjustment there is every reason for the reduction or, if possible, the elimination of waste, and the managers and engineers of the steel and iron industry have been alive to the advantages resulting from the conservation of fuel. There are, however, in this and in all allied by-product industry, a number of opportunities for reduction in the consumption of fuel, some of which have been discussed many times and others only briefly touched upon.

In order to show the relative proportion of the energy in the shape of heat or power required for the manufacture of steel that is utilized from the fuel by-products of the manufacturing process, the following figures have been prepared showing the quantity of heat derived from the by-products of the manufacture of pig iron.

In the production of one ton of pig iron, from under 1800 to over 3000 lb. of coke are used, this variation being due to difference in metallic content of the charge, condition of the furnace lining, quality of coke, etc. The heat energy of this coke is utilized in the reduction of the ore to pig iron and changing the impurities to a slag; a part is lost in radiation, and approximately half is delivered at the top of the furnace in the shape of gas for use under boilers for the production of steam, or in gas engines for the production of power. The gas has also been used in soaking pits, in by-product oven heating, ladle drying, etc., and other uses have been proposed, but by far the greatest quantity has been used under boilers.

It has been only within the last few years that blast-furnace gas has been considered to have any material value. The value generally placed upon gas, and appearing as a credit to blast-furnace cost, has been based upon the cost of the coal replaced by the gas, with an allowance for the cost of firing coal; and even with comparatively inefficient boilers, and in many cases the lack of efficient supervision, the cost of steam in these boiler plants has been generally low. The coke consumption of the blast furnaces which largely determines the volume and Btu. value of gas was variable, and the steam consumption both of the blast furnaces and of other departments supplied from the furnace plant varied widely. The credit was largely an estimate, and at times when the gas supply exceeded the demand, steam or blast-furnace gas was wasted. The blast-furnace superintendent was generally interested mainly in obtaining as high stove heats as could be carried, regardless of how much gas was wasted at the stoves through leaving the gas on after they had become heated, or by forcing gas to the stoves above their efficient combustion capacity. Gas was similarly wasted at boilers, due to too small combustion chambers, inefficient gas burners, lack of proper baffling, or lack of proper attention paid to combustion. With nominal coal costs this waste might be excused but with the realization that coal deposits have a limit and with the increasing value of coal and its by-products, any waste of fuel should be stopped provided the cost of eliminating the waste is not excessive.

In the past there has been no recognized method of determining whether or not a blast-furnace plant has been guilty of wasteful practice, or if guilty, what the extent of this waste might be, and it is the intention of this paper to propose a standard method of comparison of total combustion efficiency, both with the idea of determining, for any particular plant, the relative efficiency, from day to day or month to month, as well as for the comparison of one blast-furnace plant with another, for the information of the management and the engineers in determining the necessity for improvement in equipment or personnel. Reference is made particularly to the latter, for the reason that after twenty years' experience around blast-furnace plants the author has found that there is generally a greater gain in efficiency possible per dollar of expenditure by efficient attention to operation of existing equipment, than by making changes in equipment without proper supervision.

Heat Available From the Blast Furnace.

In proposing this standard comparison reference is

For presentation at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of The American Society of Mechanical Engineers, 29 West 39th Street, New York.

made to Fig. 1 which is taken from Mr. Brassert's paper on Modern Blast Furnace Methods, published in the year book of the American Iron and Steel Institute in 1914. This chart shows the effect of variation in coke rate upon the heat value of blast-furnace gas at 62 deg. Fahr. As blast-furnace gas leaves the top of the furnace it usually has a temperature of from under 300 to over 600 deg. Fahr., generally averaging about 400 deg. Fahr. At this latter temperature, the sensible heat of the gas is equivalent to about 8 Btu per cubic foot of gas at 62 deg. The Btu per cubic foot of blast-furnace gas according to Brassert is $62.5 + 0.016\mathbf{R}$, where $\mathbf{R}$ = lb. of dry coke per ton of pig iron; and including sensible heat of the gas at 400 deg. Fahr. would be equal to $70.5 + 0.016\mathbf{R}$. The cubic feet of gas per ton of pig iron (as shown by Brassert) is equal to $71.4\mathbf{R}$, so that in the top gas from a furnace at 400 deg Fahr. the Btu per ton of iron is $1.142\mathbf{R}^2 + 5033.7\mathbf{R}$. Brassert also gives the cubic feet of air per pound of coke equal to $51.4\mathbf{R}$, so that both gas production and the blast requirement bear a direct ratio to the coke consumption of the furnace per ton of iron. The figures given in Mr. Brassert's paper, so far as the author has been able to discover, are applicable to all blast furnaces using coke as fuel.

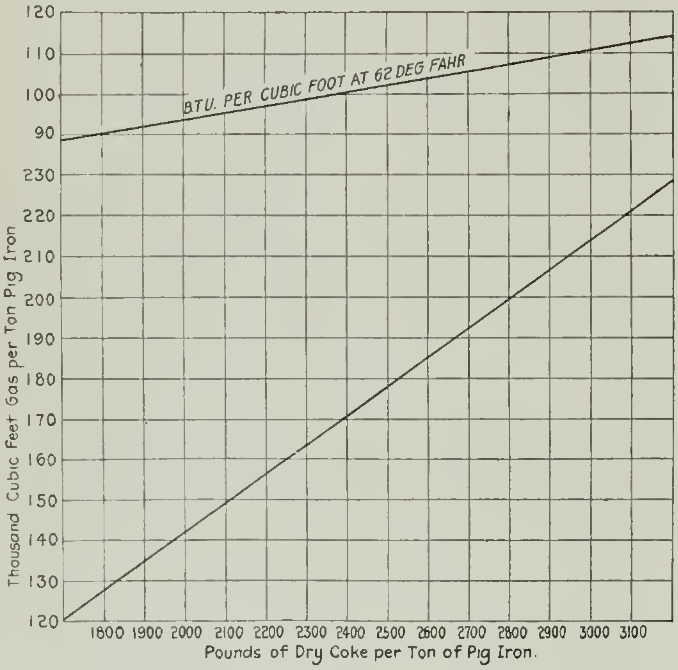


Fig. 1—Effect of coke rate on production of blast-furnace gas.

Heat Required For the Stoves.

The blast is heated in stoves under pressure, and the heat required per cubic foot of blast is proportional to the rise in blast temperature in the stove, and inversely proportional to the efficiency of the stove, which is usually considered to average 60 per cent. After the necessary gas is used to heat the blast, the remainder can be measured in the shape of power. Any increase in stove or boiler efficiency or reduction in leakage of gas, etc., is reflected in increased surplus power, and as we are largely interested in the surplus power, after the blast furnace requirements are satisfied, any error in the assumptions relative to the efficiency of the stoves is of minor importance, particularly as the stoves use the smaller fraction of the total. The blast supplied from the blowing engines is heated by compression to about 150 deg. Fahr., varying somewhat with blast pressure, etc., and is usually heated in the stoves to from 1150 to 1350 deg. Fahr. In the following calculations it has been assumed that 0.02 Btu are required per cubic foot of blast per deg. Fahr., that the blast is heated in the stoves to 1250 deg. Fahr., that the average over all stove efficiency (i. e., ratio of heat given to the blast to the heat in the gas) is 60 per cent and that 55 cubic feet of blast are heated per pound of coke charged.

The heat required in the gas for heating the blast for one ton of pig iron to a temperature of 1250 deg. Fahr. can therefore be expressed by the following formula where $\mathbf{H}$ = Btu per lb. of coke burned in the blast furnace.

$$\mathbf{H} = \frac{(1250 - 150) \times 0.02 \times 55\mathbf{R}}{0.60} = 2020\mathbf{R}$$

The heat in gas per ton product after the blast is heated is, therefore, $1.142\mathbf{R}^2 + 3013.7\mathbf{R}$. For other top temperatures and blast temperatures the constants will change slightly.

Heat Required For Gas-Fired Boilers.

In order not to enter into the discussion of the relative merits of steam vs. gas engine, surplus uncooled gas, after the stoves are heated, will be assumed to be used under boilers. In one boiler horsepower-hour there are 33,305 Btu, and assuming that the "standard" efficiency of blast-furnace-gas-fired boilers is 66.6 per cent. in one boiler horsepower-hour

$$\frac{33{,}305}{0.666} = 50{,}000 \text{ Btu would be required in the gas, so}$$

that the boiler hp-hr. per ton would be

$$\frac{\text{Surplus Btu per ton iron}}{50{,}000 \text{ Btu}}.$$

As the blast-furnace product is usually expressed in tons per day the average boiler horsepower per hour generated from blast-furnace gas under the above conditions can be expressed by the formula:

$$\text{Average boiler horsepower per hour per ton of pig iron per day} = \frac{1.142\mathbf{R}^2 + 3013.7\mathbf{R}}{50{,}000 \times 24}$$

In assuming the standard efficiency of 66.6 per cent for boilers and 60 per cent for stoves, it should not be understood that these are the maximum efficiencies that can be attained, but rather that they are taken as a standard for comparison and represent average practice that can be maintained in a fairly modern plant correctly designed, and operated by reasonably intelligent men.

Using the above, Fig. 2 has been prepared. This chart also shows the per cent of top gas required for heating the blast to an average of 1250 deg. Fahr. with the stoves of 60 per cent total efficiency. This chart can be used by the blast furnace superintendent or engineer to determine the horsepower that should have been generated from gas for any period. From the actual results as shown by a meter on the boiler feed line, after deducting an allowance for steam generated by coal firing (usually small) or for gas used by gas engines, it will be possible to determine whether the total efficiency, including stoves and boilers, is above or below the standard.

The following table shows the boiler horsepower-hours per ton of pig iron for several coke rates as calculated from the above formula.

Pound of Coke per Ton.	Boiler-Horsepower-Hours per Ton Product.	Boiler-Horsepower-Hours per Ton per Day.
2000	211	8.8
2200	242	10.1
2400	276	11.5
2600	310	12.9
2800	348	14.5
3000	386	16.1

To furnish the blast to the furnace with either high-pressure condensing, turbo-blowers or reciprocating steam engines requires about 70 boiler hp-hr. per ton of coke burned in the blast furnaces, and to operate the various furnace auxiliaries, such as pumps, air compressors, steam bells, mud guns, hoists, etc., requires from 15 to 25 boiler hp. per ton of product, so that after the furnace requirements have been met, there is available for the generation of power from 100 to 250 boiler hp-hr. per ton of pig iron, depending on the coke burned in the furnace.

At 2 kw. per boiler hp-hr., this means that from 200 to 500 kw-hr. per ton of pig iron is possible with steam equipment from the surplus gas from the blast furnaces.

Heat Required for Manufacture of Steel from Pig Iron.

The manufacture of steel from pig iron in the open hearth requires heat for melting scrap and fluxing the impurities, and power for the various operations incident to this process. The quantities of heat and power vary materially with different plants on account of difference in equipment, practice, etc., but for the purpose of this paper it will be assumed that a ton of ingots requires one ton of pig iron plus enough scrap to offset the losses and that this work requires from 5,000,000 to 9,000,000 Btu and an expenditure of from 20 to 30 kw-hr. per ton. This ton of ingots will make about 0.85 tons of blooms, and the heating in soaking pits will require from 1,500,000 to 3,500,000 Btu per ton of steel depending upon the temperature of the steel arriving at the pits, rate of operation, etc., and the rolling of the ingots into blooms will require from 40 to 60 kw-hr. per ton. From the blooming or slabbing mill the material, usually reheated at an expenditure of from 2,500,000 to 6,000,000 Btu per ton, is furnished to finishing mills, the power required, depending on the reduction of section, temperature of rolling, etc., varying from 35 to over 300 kw-hr. per ton.

Utilization of the Industrial Wastes.

Waste heat from the open hearth and heating furnaces and kilns is utilized for the production of steam, and otherwise waste steam is utilized in low or mixed pressure turbines for the production of power, but as these subjects have been discussed many times, and are not peculiar to the steel industry, they will not be discussed except to say that while these economies are many times worth while in existing plants, very few new installations as designed include waste-heat boilers with furnaces, or low-pressure turbines as integral parts of new power plants.

Surplus by-product gas, after the ovens are heated, is sold for use as domestic fuel, etc., replacing natural gas, water gas, etc., and is used in the steel plant for melting steel in the open hearth, and for various heating operations in the steel industry. In former years this material was considered as having only nominal value and only rarely was any attempt made to utilize it efficiently.

With the advance in fuel prices, shortage of natural gas, etc., and also largely due to special heating requirements connected with the manufacture of artillery and ammunition during the war, a number of combustion systems were developed that by more or less accurately regulating the proportion of air to gas have greatly increased the combustion efficiency of heating furnaces, and the control of combustion has been found of great importance in the maintenance of economy.

Dust coke breeze, from the coke plant (i. e., the material through a $\frac{3}{8}$-in. screen), is used to cover molten pig iron in transit from the furnaces and in making bottoms of soaking pits and heating furnaces.

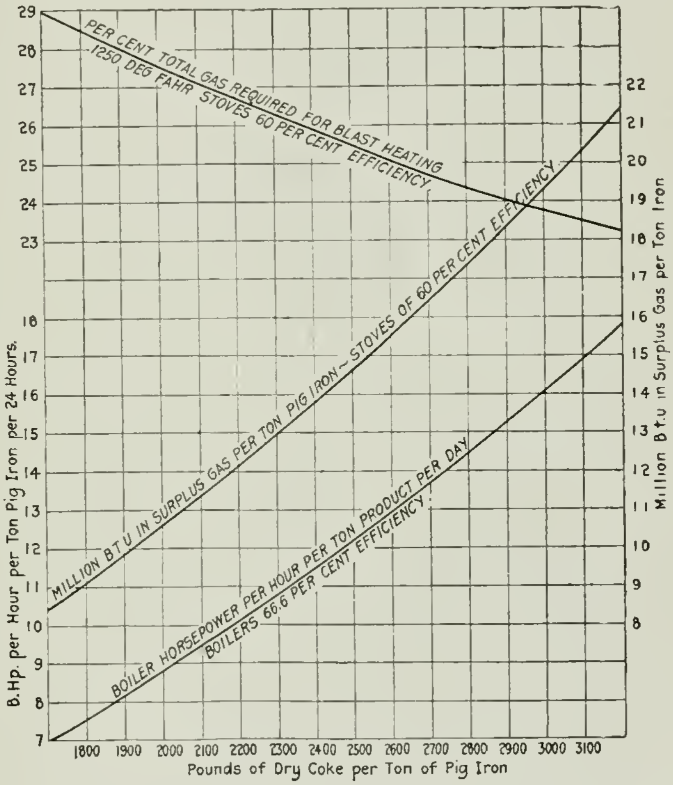


Fig. 2—Effect of coke rate on production of power from surplus blast-furnace gas.

A great deal of this material which was thrown away or more or less inefficiently burned on hand-fired grates, or by mixing with slack, on mechanical stokers, is now more efficiently burned by itself, on traveling-grate forced-blast stokers.

Tar, either before or after the creosote oils have been removed, has been found to be a very good fuel for open-hearth furnaces, either by itself or in conjunction with by-product gas, and has been used for steam production either as an auxiliary fuel on blast-furnace boilers or by itself, and its use has been proposed to heat by-product ovens, thus releasing additional gas otherwise required for heating the ovens.

Heat Balance.

Table 1 gives an example of the approximate heat balance of one ton of pig iron as used in the steel plant, using average figures, and based on an average coke consumption in the blast furnace of 2500 lb. of coke per ton of product.

TABLE 1.

Heat balance for manufacture of one ton of pig iron.

From the coke plant delivering one ton of coke there result the following fuel by-products for consumption in the steel plant after the heat and power requirements of the by-product plant have been met:

	Btu.	Btu.
12 gal. tar at 162,500 Btu per gal., Btu....	1,950,000	
30 lb. of coke breeze at 12,000 Btu per lb., Btu.	360,000	
10,000 cu. ft. gas at 500 Btu per cu. ft. (net value), Btu	5,000,000	
Total per net ton coke		7,310,000
Heat available per ton pig iron		
In tar from by-product plant	2,435,000	
In coke breeze from by-product plant...	450,000	
In surplus gas	6,250,000	
Surplus from by-product plant		9,135,000
In blast furnace gas		19,635,000
Required for blast heating	5,000,000	
Required for blowing equipment	4,400,000	
Required for blast-furnace operation....	1,000,000	
Required for total blast furnace		10,400,000
Surplus from blast-furnace plant		9,235,000
Total heat energy from by-products		18,370,000
Heat required for steel plant		
Open hearth (pig iron to ingots)		
Melting (approx)	7,000,000	
Power, 25 kw. at 25,000 Btu per kw-hr....	625,000	
Total heat consumption		7,625,000
Roughing Mill		
Heating (approx.)	2,000,000	
Power, 50 kw-hr	1,250,000	
Total		3,250,000
Finishing Mill		
Heating (approx.)	4,000,000	
Power, 100 kw-hr	2,500,000	
Total for finishing		6,500,000
Total heating requirements	13,000,000	
Total power requirements	4,375,000	
Total		17,375,000

Necessity of Heat Conservation.

From Table 1 it will be seen that the total heat from the by-products of a ton of pig iron is more than sufficient to finish the average ton of steel, but upon inspection of the table it will be found that the heating requirements have not been met from tar and by-product gas, while the average power requirements are more than met from blast-furnace gas and coke breeze.

It therefore becomes very desirable to reduce the heating requirements for production of steel by using more efficient heating furnaces, and to conserve all possible heat by charging hot steel into the soaking pit and reheating furnaces, in order to reduce the quantity of fuel required for supplementary heating.

The production of gas at the by-product plant is practically uniform, while the consumption at the steel plant is variable and as a result the gas pressure at the steel plant (usually some distance away from the by-product plant) is variable. As gas holders of sufficient capacity to absorb the fluctuations have not been found advisable it becomes necessary to schedule the use of gas by consuming departments in order partially to equalize the consumption. In many cases it is advisable to use by-product gas under boilers (although it is more valuable for other purposes) in order to prevent or reduce its waste, as it is easier to change from gas to coal on boilers than to fire up producers.

One of the most important problems of the steel plant manager and engineer is so to regulate the production and consumption of the various fuels occurring as a by-product of steel plant manufacture that the consumption of raw coal in producers or under boilers that would otherwise be sent to the by-product plant is a minimum, for the reason that the by-products from the coal, coked in the by-product plant, usually exceed any possible return as fuel.

PUBLICATIONS ON THE UTILIZATION OF COAL.

A limited supply of the following publications of the Bureau of Mines has been printed and is available for free distribution until the edition is exhausted. Requests for all publications can not be granted, and to insure equitable distribution applicants are requested to limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines.

The Bureau of Mines issues a list showing all its publications available for free distribution as well as those obtainable only from the Superintendent of Documents, Government Printing Office, on payment of the price of printing. Interested persons should apply to the Director, Bureau of Mines, for a copy of the latest list.

Publications Available For Free Distribution.

Bulletin 40. The smokeless combustion of coal in boiler furnaces, with a chapter on central heating plants, by D. T. Randall and H. W. Weeks. 1912. 188 pp., 40 figs.

Bulletin 58. Fuel briquetting investigations, July, 1904, to July, 1912, by C. A. Wright. 1913. 277 pp., 21 pls., 3 figs.

Bulletin 116. Methods of sampling delivered coal, and specifications for the purchase of coal for the Government, by G. S. Pope. 1916. 64 pp., 5 pls., 2 figs.

Technical Paper 9. The status of the gas producer and of the Internal-combustion engine in the utilization of fuels, by R. H. Fernald. 1912. 42 pp., 6 figs.

Technical Paper 50. Metallurgical coke, by A. W. Belden. 1913. 48 pp., 1 pl., 23 figs.

Technical Paper 80. Hand firing soft coal under power-plant boilers, by Henry Kreisinger. 1915. 83 pp., 32 figs.

Technical Paper 89. Coal-tar products and the possibility of increasing their manufacture in the United States, by H. C. Porter, with a chapter on coal-tar products used in explosives, by C. G. Storm. 1915. 21 pp.

Technical Paper 123. Notes on the uses of low-grade fuel in Europe, by R. H. Fernald. 1915. 37 pp., 4 pls., 4 figs.

Technical Paper 137. Combustion in the fuel bed of hand-fired furnaces, by Henry Kreisinger, F. K. Ovitz, and C. E. Augustine. 1916. 76 pp., 2 pls., 21 figs.

Technical Paper 139. Low-rate combustion in fuel beds of hand-fired furnaces, by Henry Kreisinger, C. E. Augustine, and S. H. Katz. 1918. 52 pp., 9 figs.

Technical Paper 180. Firing bituminous coals in large house-heating boilers, by S. B. Flagg. 1917. 22 pp., 1 pl., 16 figs.

NEWS OF THE PLANTS

The Petroleum Iron Works, Sharon, Pa., is concluding negotiations for the purchase of the plant of the Beaumont Shipbuilding & Dry Dock Co., Beaumont, Tex., for a consideration said to be about $300,000. The plant upon acquisition will be used as a southern branch works for the manufacture of oil tanks, tank cars, etc. The site approximates about 71 acres, and early proposed expansion will include the erection of a number of new buildings to be equipped as a complete steel fabricating works. The property is being secured in the name of the Petroleum Land Company, a subsidiary organization.

The Gerson Rolling Mills Corporation, Birmingham, Ala., is perfecting plans for the early erection of an addition to its plant for increased production. The primary installation will consist of a new mill for the manufacture of steel bar stock, and it is proposed to double the output in this and other departments. The expansion is estimated to cost about $100,000.

The Worcester Pressed Steel Company, Worcester, Mass., is arranging for the early installation of new precision cold rolling mills for flat strip steel production, and it is planned to provide for extensive increase in this department of the works. The mills will be equipped with steel rolls, 6 inches in diameter and of 4-inch face, permitting a maximum width of stock rolled of 3⅝ inches. The new mills will be motor-driven.

The General Iron Works Company, Denver, Colo., has acquired a large tract of land at Englewood, Colo., totaling about 18 acres, and plans to use the site for the erection of a new plant. Plans will be prepared at an early date, covering the construction of a number of one-story buildings, estimated to cost about $750,000, including machinery. The different structures will be devoted to general iron working, steel fabrication, steel casting production, etc. Erection will be commenced early in the summer, and it is proposed to have the initial buildings ready for service late in the fall. The various departments will be used by the different subsidiaries of the company, including the Colorado Iron Works, the Denver Engineering Works, the Queen City Foundry Company and the Stearns-Rodger Manufacturing Company.

The Dominion Alloy Steel Company, recently organized with a capital of $15,000,000, has plans under way for the erection of a new plant on site selected at Sarnia, Ont., for the manufacture of high carbon steel, steel alloys and kindred products. The plant will consist of a number of buildings and will be equipped for an initial output of about 50,000 tons of material per year. The company has arranged for a bond issue of $3,500,000, to provide for erection and equipment. George A. Simpson, Hamilton, Ont., is vice-president of the company and will be in active charge of the project. The directors of the company and officials in charge include Harry R. Jones, head of the United Alloy Steel Corporation, Canton, Ohio, and Harold Wills, head of the Wills-Sainte Clare Automobile Company, Marysville, Mich.

The Sloss-Sheffield Steel Company, Montgomery, Ala., has tentative plans under consideration for the construction of an addition to its plant for considerable increase in capacity. The work will include a new blast furnace with daily output approximating 250 tons.

The Riverdale Rolling Mill Company, East One Hundred and Thirty-seventh Street and the tracks of the Illinois Central Railroad, Chicago, Ill., is planning for the rebuilding of the portion of its plant destroyed by fire, March 25, comprising a large two-story structure. The loss is estimated at approximately $50,000, including equipment.

The Cadillac Malleable Iron Company, Cadillac, Mich., has work under way on an addition to its plant for increased output, comprising a one-story building, 120 x 200 feet, to be devoted to general iron working. It is planned to construct other additions at a later date.

The Andrews Steel Company, Newport, Ky., has secured options on property forming a portion of the former works of the Hecla Cement Company, Bay City, Mich., totaling about 150 acres of land and a number of buildings, as a site for the establishment of a new steel mill. It is said that the purchase will be made at an early date. A number of other buildings will be erected and the present structures improved to accommodate the new industry. The equipment installation will provide for the manufacture of steel billets, bars, black and galvanized sheets and kindred products. A new blast furnace is also projected. The company has been operating at Newport, and it is said that the change is being considered owing to the continuance of labor troubles. Articles of incorporation were filed recently under Delaware laws with a capital of $750,000, headed by W. N. and Joseph B. Andrews, Newport, now operating the Kentucky Rolling Mills in that city.

The Union Iron Works, Fifteenth and Cascade Streets, Erie, Pa., is planning for the rebuilding of the portion of its plant destroyed by fire on March 23, with loss estimated at close to $350,000, including buildings and equipment.

The Northwestern Steel & Iron Works, Eau Claire, Wis., is planning for the early rebuilding of the portion of its plant recently destroyed by fire, with loss approximating $150,000, including machinery.

The Danville Iron & Steel Company, Danville, Pa., has tentative plans under consideration for the erection of an addition to its plant for increased capacity. The structure will be one-story and it is proposed to break ground during the spring.

The Eastern Malleable Iron Co., Naugatuck, Conn., is planning for the erection of a new plant building at Watervliet, N. Y., consisting of a one-story building, 50 x 250 feet, estimated to cost in excess of $30,000. The company will also erect a new power plant at the works.

The Northwestern Iron Works, Devils Lake, N. D., has preliminary plans under consideration for the erection of an addition to its plant for increased production, to consist of a main two-story building, with subsidiary structures. It is said that the extension will cost close to $55,000.

PRODUCTION TOPICS

THE PURCHASE OF REFRACTORIES*

By W. A. HULL, Chief, Refractories Section,
Bureau of Standards, Washington, D. C.

The Government has gone in for business methods, and one of the things that is getting a beneficial shaking up is the system of purchasing. Now it so happens that there is, in the Federal Government, a Department of Commerce. There are several classes of people in the United States, including many of our important manufacturers, who are not as keenly or as constantly aware of the existence of the Department of Commerce as of one or two of the other Departments. Some of them doubtless think of the Department of Commerce simply as the Department of which Mr. Hoover is Secretary. Well, that is not a bad introduction to it, in case one has never made its acquaintance before. Not only is Mr. Hoover Secretary but the whole Department knows he is Secretary and has known it for some time. He has taken the secret out of secretary and given the Department a dynamic form of government. That is a mighty good thing, for the Department of Commerce is naturally called on for full steam ahead.

It was entirely logical and natural that the Bureau of the Budget, in taking up the problem of systemizing the Federal purchases, should find some things lacking in the matter of specifications. This led to the creation, by executive order, of a Federal Specifications Board, with Dr. Stratton, Director of the Bureau of Standards, as Chairman. Now the matter of specifications was by no means new to the Bureau of Standards, or to Director Stratton or to Mr. Hoover. In fact Mr. Hoover had made a most impressive demonstration of what could be done with specifications—of the right kind and used in the right way. In making wartime purchases of clothing, blankets and provisions for use in the Belgian Relief work, he had been amazed at the extremely reasonable prices at which goods of excellent quality could be obtained by the purchase of a large quantity of a single article to be made to a simple, definite specification. Now to make a specification, it is necessary to have standards of quality. Mr. Hoover found the Bureau of Standards working on standards of quality and he gave the signal to step on the gas.

And this is merely a bit of current history to make it clear why the Bureau of Standards is interested in the purchase of refractories.

The guiding star in all the research work on standards of quality and in the preparation of specifications is the elimination of waste. Standards of quality tend to prevent uncertainty and confusion. They tend to prevent the purchase of high priced things where low priced things would do as well; they tend to prevent the use of low priced things where high priced things are required and would be an economy; and sometimes they prevent buying the high priced thing when there is a better quality to be had at a lower price. This last occurrence is not at all unusual—not nearly as uncommon as it should be.

At the Bureau of Standards we receive requests from consumers for specifications for all sorts of things. Those who make these requests want something that will insure their getting good goods. They cannot be guided entirely by the price of these things nor by what the advertisements say about them. In some cases it is extremely difficult to judge of relative values by performance in service. Take paints, for example, and lubricating oils; you manufacturers know how hard it is to tell what you are getting for your money in things like this. The same is true, though to a less extent, in the purchase of dishes. Large purchasers of hotel china are keenly interested in standard tests for tableware and the Bureau is supplying them. Until these tests were put in use we did not know that we were making better hotel china at home than we were importing from Germany, England and even from France. Now that we are testing dishes, we can say that when specifications for this class of goods go into effect, the foreign producers will have something to worry about besides the tariff.

A number of the Governmental Departments are considerable users of refractories and one of the things that the Federal Specifications Board has taken up is specifications for refractories. A survey of the situation brought out the fact that the purchasing methods of the various Departments were not at all the same. One Department was buying on specifications and another was not and the specifications of one Department were not similar to those of another. As a result of this condition, the Bureau of Standards was asked to draft specification for the types of refractories that are purchased by the Government Departments.

Now the less one knows about refractories, the easier it is to write specifications. Perhaps it would be better to say that in order to make a good job of it, it is necessary to have a large amount of information and at the same time a reasonable allowance of common sense. Now at the Bureau of Standards we may have common sense enough for a job like this—anyhow we had sense enough to know that we didn't have anywhere near enough information; so we sent for more. As a result, some of the best equipped men in the United States, from both the producing and a number of consuming industries have responded to the invitation to join forces and work this thing out together. Two of these conferences have been held. At the first, the whole subject of tests was discussed, up one side and down the other. Everyone's opinion on every standard or near standard test was brought out. The effect was that of clearing the decks for action. In the second conference, a complete set of requirements for fire brick for coal fired boilers was drawn up. Of course there are special conditions encountered in the use of different kinds of coal in different types of boiler furnaces and it would be impossible for any group of men to draw up in one day specifications for all the special qualities of refractories that would be best suited to meet them. We thought we had done a day's work when we had expressed, in terms of simple test reuirements, what we would consider a satisfactory grade of brick to take care of the common run of modern, high duty, coal fired boiler service, but we put in a little overtime and wrote up the requirements for the clay.

Of course these requirements have not been decided on in anything like a final way but we have a conviction that that day's work is a milestone in the progress of the refractories industry for this is the first instance that we know of where American producers and consumers have joined forces and drafted even a tentative set of specifications for refractories for a specific service. It may be that it is only now that the industries are ready for such a thing.

(To be continued next month)

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The Open Hearth

Bracken Todd

Bracken Todd, assistant superintendent of the blooming mills at the Monessen plant of the Pittsburgh Steel Company, has resigned his position to become superintendent of the rolling mills of the Andrews Steel Company at Newport, Ky. Mr. Todd has been associated with the Pittsburgh Steel Company for the past nine years.

At his departure from Monessen Mr. Todd was presented by the blooming mill employes with a gold watch and chain. Mr. Todd assumed charge of the rolling mills at Newport on April 15.

V V

A. P. Blackstead, formerly chief engineer of the Camden Iron Works (R. D. Wood & Co.), Camden, N. J., and prior to that hydraulic engineer with the Henry R. Worthington Company, New York, has joined the engineering staff of the Dayton-Dowd Company, manufacturers of centrifugal pumps and approved underwriters' fire pumps. Mr. Blackstead has recently returned from Europe where he spent six months studying conditions and investigating recent developments in hydraulic engineering.

V V

Howard K. Moore, secretary of the Portsmouth-Solvay Coke Company prior to its joint absorption by the Wheeling Steel Corporation and the American Rolling Mill Company, has been appointed assistant general manager of the Steubenville, Ohio, works, Wheeling Steel Corporation. Mr. Moore was assistant to Andrew Glass, president of the Whitaker-Glessner Company at Portsmouth, Ohio, for a number of years and previously had steel works experience in the eastern plants. Mr. Moore is a brother of G. W. Moore, general superintendent, Portsmouth, Ohio, works of the company.

V V

Wm. H. Weichsel has resigned as manager of the Dover Works, the American Sheet & Tin Plate Company, Dover, Ohio, to become manager of the sheet mills of the Inland Steel Company, Indiana Harbor, Ind., effective April 1. W. H. Ashbaugh, Leechburg, Pa., has been appointed to succeed him. Mr. Weichsel has been in the steel business for 19 years, having started with the Aetna Standard works at Bridgeport, Ohio. For the past six years he has been at Dover, first as superintendent and for the past year as manager.

V V

Henry F. Favor, superintendent, Crompton & Knowles Loom Works, Providence, R. I., sailed March 16 from Vancouver, B. C., for China and Japan on a business trip.

V V

S. W. Tarr has been made chief engineer of the Oliver Iron Mining Company, succeeding the late Alexander M. Gow. Mr. Tarr was formerly superintendent of construction in the mechanical division of the company.

V V

Fred Heiser has been made foundry superintendent of the malleable department of the Superior Steel Casting Company, Benton Harbor, Mich. Mr. Heiser formerly had charge of the malleable foundry of the Timken Detroit Axle Company, Canton, Ohio.

V V

Wiley H. Marble, formerly manager of the American Stainless Steel Company, Pittsburgh, is now affiliated with the Palmer Engineering Company, 335 Fifth Avenue, that city. This company designs stokers, etc.

V V

Ernest McKay has resigned his position as works superintendent of the Nova Scotia Steel & Coal Company to go to Pittsburgh, where he will engage in the steel industry.

V V

Baltzar De Mare, metallurgist and more recently steel superintendent for the Midvale Steel & Ordnance Company for approximately 20 years, now has been appointed general manager of the Union Electric Steel Company, Carnegie, Pa.

V V

Robert Gregg, secretary and treasurer of the Atlantic Steel Company, Atlanta, has been elected president of the company, succeeding Thomas K. Glenn, who has been made chairman of the board of directors. Mr. Gregg is one of the country's youngest steel presidents, being only 37 years old. He was born in Atlanta, April 14, 1885; was educated in the public and preparatory schools there and was graduated from Georgia School of Technology as a Bachelor of Science in 1905, and next year completed a post-graduate course at Cornell with the degree of Mechanical Engineer. In August that year he entered

The Open Hearth

the employ of the Atlantic Steel Company as a clerk in the general superintendent's office. A year later he was transferred to the open hearth department, serving as a helper on furnaces. Then he was made a cost accountant and in 1909 was placed in charge of the accounting department and in 1912 was made secretary of the company in which he also is a director. Later he was made treasurer. Besides membership in several local organizations, Mr. Gregg is a member of the American Iron and Steel Institute.

√ √

Nelson J. Darling, assistant general manager of the Erie, Pa., works of the General Electric Company, has been elected manager of the River Works, Lynn, Mass., of the company, to succeed Richard P. Cox, who has been acting manager of the West Lynn, Mass., works, but recently promoted to manager.

√ √

William J. Priestly, formerly steel superintendent, naval ordnance plant, South Charleston, W. Va., has been appointed works manager, Pittsburgh Crucible Steel Company, Midland, Pa., succeeding H. P. Barnard, resigned, and has assumed his new duties. Prior to going to the naval ordnance plant, Mr. Priestley was a division superintendent at the Lehigh plant of the Bethlehem Steel Company. He was graduated from Lehigh University, class of 1908.

√ √

L. A. Touzalin, assistant superintendent, blast furnaces, South Works, Illinois Steel Company, Chicago, has been appointed superintendent of blast furnaces at Joliet Works, Joliet, Ill. Harry Strain succeeds Mr. Touzalin at South Works.

√ √

Lane Johnson has assumed his duties as chief engineer of the United Engineering & Foundry Company, Pittsburgh, having been previously engaged in consulting engineering work in the Pittsburgh district. He is a graduate of the Massachusetts Institute of Technology and has a broad experience in mill work. Among the firms with which he has been connected are the Colorado Fuel & Iron Company, Kokomo Steel & Wire Company, American Rolling Mill Company and Alex Laughlin.

√ √

C. E. Potts, superintendent of the sheet mills of the Inland Steel Company, Indiana Harbor, Ind., has resigned, effective April 1, on account of ill health, and will make his home in Los Angeles, Cal. Mr. Potts is succeeded by William H. Weichsel, formerly superintendent of the Dover mill of the American Sheet & Tin Plate Company, New Philadelphia, Ohio.

√ √

Walter J. Muncaster, vice president and general manager of the Cumberland Steel Company, Cumberland, Md., has resigned, after having held the position for 30 years. He was one of the organizers of the company for the manufacture of ground shafting, under patents granted to him.

√ √

F. G. Peterson has resigned his position as foundry superintendent for the Bucyrus Company, South Milwaukee, Wis.

√ √

C. J. McGregor, who for the past five years has been assistant sales agent in the Cleveland district of the American Steel & Wire Company, has been made sales agent for the company in the Buffalo district, effective April 1. Mr. McGregor has been with the American Steel & Wire Company over 20 years, always in a sales capacity, and had been stationed at Chicago and Worcester prior to coming to Cleveland. He succeeds at Buffalo, E. A. Niven, who is being transferred to the sales organization of the company at New York. The position of assistant sales agent at Cleveland will be filled by P. B. Gilroy, now attached to the Detroit office of the company.

√ √

W. C. Peterson has resigned as metallurgical engineer for the Atlas Crucible Steel Company to become manager of the Alloy Steel Division of the Electric Alloy Steel Company, Youngstown, Ohio. Mr. Peterson for 12 years prior to his Atlas Crucible Steel Company connection was supervisor of materials in charge of metallurgical laboratories, heat treating departments, etc., of the Packard Motor Car Company.

√ √

Guy Weir, assistant superintendent, Eliza Furnaces, Jones & Laughlin Steel Company, has resigned to accept the position of superintendent of blast furnaces for the Pittsburgh Crucible Steel Company, Midland, Pa. Mr. Weir, who has been with the Jones & Laughlin Steel Company for the past ten years, succeeds Harry H. Hodgett, resigned.

√ √

Edward T. McNulty has resigned his position as superintendent of the Wheeling Steel Corporation's Yorkville, Ohio, plant to become general manager of the Charcoal Iron Products Co.

Some Pointers on By-Product Coke Oven Operations

THE KOPPERS COMPANY DEVELOPS NEW BY-PRODUCT COKE OVEN.

Announcement has been made by The Koppers Company of the development of a new type of by-product coke oven which promises to revolutionize by-product coke oven practice in this country. The design of this oven was developed by Joseph Becker, Consulting Engineer of The Koppers Company, and is covered by patents by The Koppers Company. A battery of these ovens has been in continuous operation at the plant of the Chicago By-Product Coke Company since the latter part of January. The average coking time has been under 11 hours and on tests this oven has carbonized coal in 9½ hours.

Since beginning operation these new Koppers ovens have been inspected by representatives of many of the large steel companies, all of whom have been most enthusiastic in their praise of this new design. In the judgment of one prominent coke oven man who was interviewed, this new oven will prove to be the most efficent by-product coke oven ever developed.

The outstanding feature of this new Koppers oven is the perfect heat control obtained, which insures a coke that is ideal for metallurgical purposes. Blast furnace operators who have examined this oven and the coke produced have stated that it is their belief that the use of coke made in this type of oven will make possible much more efficient blast furnace operation. Tests have been made with these ovens on many different grades of coal, including the straight high volatile coals from Pennsylvania and Kentucky, and Illinois coal, with excellent results.

In this connection it is pointed out by The Koppers Company that there is nothing new in making coke from Illinois coal. This has been done for a number of years in Koppers ovens; in fact in 1917 the Bureau of Standards conducted a test at the Koppers Plant of the Minnesota By-Product Coke Company, St. Paul, Minnesota, and the results obtained conclusively proved that a satisfactory grade of metallurgical coke could be made in the standard Koppers oven from Illinois coal. Other Koppers plants in the middle west district have also used Illinois coal with equally good results.

The perfection of this new Koppers oven is the consummation of many years' study and research work which The Koppers Company has devoted to the improvement of by-product coke oven practice in this country and is a striking example of the value of such a company to industry as a whole. In the opinion of the coke oven superintendents and blast furnace men who have inspected this new type of oven, its successful operation and the excellent results obtained mark the greatest stride in this industry in many years.

No detailed description of the design of this oven has been given out by The Koppers Company as yet, but it is expected that this will be made public in the near future. In an interview H. B. Rust, President of The Koppers Company stated that in his judgment this new oven will meet with such universal favor in the industry that it was very doubtful if The Koppers Company would ever build another oven of its old design.

THE CLAUDE PROCESS FOR PRODUCING SYNTHETIC AMMONIA.

A comprehensive description of the process and plant was given in a paper read by Mr. J. H. West, before a joint meeting of the Society of Chemical Industry, and the Institution of Mechanical Engineers.

The process consists of the direct combination of hydrogen and nitrogen under pressure, in the presence of a catalyst, the essential difference between this and the Haber process, being the 200 atmospheres in the latter case, against the 900 atmospheres in the former. There are many advantages to be derived from the Claude process, however. At any given temperature, the proportion of hydrogen and nitrogen remaining combined under conditions of equilibrium, increases rapidly with increase of pressure. Another point of importance with high pressure, is the very small pipes required; furthermore, a practical advantage is the heat produced with 900 atmospheres, whereby small catalyst vessels, heated externally and electrically, may be employed.

Interesting particulars are given of the super-compressor machine, a remarkable feature of which is its simplicity. Comparisons are also made between the time to heat up after a stoppage; against the three days of the Haber plant, 4-5 hours suffice with the Claude.

Carbon monoxide, which is liable to be present in hydrogen obtained from water gas or coke-oven gas, is eliminated by the Claude process, and this, together with suitable methods for obtaining the hydrogen and nitrogen, is described.

A further advantage of the high pressure, is the simple method of collecting ammonia in liquid form by merely cooling the gas to atmospheric temperature.

In conclusion, interesting comparative figures are given of the cost of power required for producing one ton of ammonia from coke-oven gas and from electrolytic hydrogen.

ORIGIN AND CHEMISTRY OF COALS AND SHALES.

An extensive investigation is being conducted by the Bureau of Mines regarding the origin, composition and chemistry of coals, cannel coals, and boghead coals. The coals from various beds and localities are examined microscopically. Thin sections are cut and examined at all magnifications; the constituents forming coal are examined and certain characters are recorded photographically. Coals may thus be studied concerning their nature, quality and various characteristics. The kinds, relative amounts and nature of the various constituents are studied and correlated with their distillation products and other qualities and characteristics shown in relation to their economic uses, such as coking, gas production, steaming, etc. Oil shales and cannel slates are also being studied by the Bureau of Mines as to their origin, composition and chemistry. Thin sections are cut and studied under the microscope and characters recorded photographically. The mineral matter is removed by means of acids and the remaining organic matter examined and compared with thin sections. The organic matter is burned out at low temperatures and the remaining mineral matter also examined and compared with thin sections. The kinds, nature and relative amounts of the various constituents are thus studied and correlated with the kinds, nature and relative amounts of distillation products.

TRADE PUBLICATIONS

The Uehling Instrument Company, Paterson, N. J., have published a new bulletin No. 112, covering Uehling CO_2 recording equipment, for guiding operating boiler plant engineers in the reduction of the waste of fuel up the chimney. Particular attention is called to the company's recently developed "Pyro-porus" filter which is used to keep the gas sampling lines clean.

The Deschanel Engineering Corporation, New York, N. Y., in an 8-page booklet illustrates and describes the Deschanel cableway, hoists and buckets.

The Kay Mfg. Company, Norwalk, Conn., calls attention to its new bulletin entitled "Whitney Free Floating Coupling," which is designed to transmit power from one shaft to another, though the shafts are not in alignment, without causing strains in the shafts or bearings. Disassembled couplings are shown, dimensions are given and also a price list.

The Oliver-Sherwood Company, San Francisco, Cal., a subsidiary of the Oliver Continuous Filter Company, has issued a new catalog on "Cutless Bearings." Illustrations are given as well as a description of the weak link in every pump, the secret of cutless bearing, the elimination of expense of machining, the many uses of cutless bearings and a list of pump manufacturers using the bearings.

The Norton Company, Worcester, Mass., in a 40-page booklet, illustrates and describes "Alundum Safety Tile," which is for stair treads, floors, ramps, elevator landings, entrances to public buildings or wherever a slip-proof, non-wearing surface is desired. Illustrations and descriptions are given on materials and process of manufacture, its advantages, general characteristic of physical properties, types and sizes and specifications for the proper installation of alundum safety tile. Interesting illustrations are given of the actual use of this tile in buildings, subways, stairs, floors, etc.

The Fulton Foundry & Machine Company, Cleveland, Ohio, describes the Airedale clutch in a bulletin just issuel. This clutch is made for services from 6 to 660 hp. in standard sizes, and is applicable for a wide range of machines in many kinds of industries. The clutch will not "grab," but picks up gently and is simple and ruggedly made.

The Merrill Company, San Francisco, Cal., announces it snew catalog, "Merco Processes and Products." Descriptions are given of the Merco precipitation processes and products and also some of the up-to-date results achieved by representative installations, as well as descriptions of the Crowe vacuum-zinc shavings process, Merrill sluicing clarifying filter, Merco-Nordstrom plug valve, Merrillite and Merco methods for clarifying and precipitating cyanide solutions.

The Philadelphia Drying Machinery Company, Philadelphia, Pa., has recently issued a 4-page folder which describes the various types of "Hurricane" driers for chemicals, battery platés, pharmaceuticals, electrical porcelain, leather, tobacco, spark plugs, food products, etc. The truck tray drier is described as well as the storage battery late drier, the tunnel truck driers, automatic conveyor type of drier, cabinet tray drier, continuous sectional conveyor drier and "Hurricane" automatic combination stick and apron tobacco drier.

The Wellman-Seaver-Morgan Company, Cleveland, Ohio, has issued Bulletin 71 descriptive of the application of labor-saving machinery, particularly car dumpers, excavators, filling bridges and excavating bridges. It also describes the practical method of working very low grade ore, especially by the leaching process.

The Colorado Iron Works Company has issued Pamphlet 33, on "The Akins Flotation and Aeration Machine."

The American Steam Gauge & Valve Mfg. Company of Boston, Mass., is distributing a folder describing its recording thermometer which has recently made its appearance on the market. This new product is actuated by different methods, depending on the purpose, and either saturated vapor expansion, inert gas or liquid is employed. It is in a 10-in. moisture-proof case to record any temperature up to 1,000 deg. F. at any distance up to 200 ft.

The Uehling Instrument Company, Paterson, N. J., announces two new publications: Bulletin 220, on "Magnitude of the Power Plant's Chimney Loss," and Bulletin 221, on "Relation Between CO_2 and Money Wasted Up the Chimney."

TRADE NOTES

The Freeport Sulphur Company, New York and Freeport, Texas, awarded contract on March 2 to Dwight P. Robinson & Company for the design and construction of a complete sulphur mining plant at Hoskins Mound, Texas. Cloyd M. Chapman has been retained by the Freeport Sulphur Company as consulting engineer.

Freyn, Brassert & Company announce that the following officers have been named in their company: F. H. Willcox, vice president; Wyman Eaton, vice president; L. T. Shorley, secretary.

The Electric Furnace Company has moved its general and sales offices from Alliance, Ohio, to Salem, Ohio. By this action all departments of the company will be consolidated at its work, Wilson Street and Pennsylvania Railroad, Salem, Ohio.

The Sharon Pressed Steel Company have made the following appointments in their sales forces: W. C. Ames has been appointed district sales manager at 20 East Jackson Blvd., Chicago, Ill.; Ralph E. Phillips has been appointed district sales manager with headquarters at 66 Broadway, New York City.

Combustion Engineering Corporation announce the opening of a new branch office at 1137 Guardian Bldg., Cleveland, Ohio. The office will be in charge of Frank Henderson, a prominent stoker man.

Detroit Seamless Steel Tubes Company of Detroit, Mich., makers of cold drawn seamless boiler and mechanical tubing, have just established their own branch sales office in New York City. It is located in the Canadian Pacific Bldg., 342 Madison Ave., between Forty-third and Forty-fourth Sts. A noteworthy addition is the appointment of H. C. Kensing as district sales manager for the New York territory.

Freyn, Brassert & Company, Chicago, have been retained as consulting engineers by the Cranberry Furnace Company of Johnson City, Tenn.

The Chain Belt Company, Milwaukee, Wis., has announced the appointment of G. F. Sherratt as manager of the Pittsburgh office in the Union Arcade Bldg. The Ward Equipment Company of Pittsburgh will continue to handle the complete line of Rex concrete mixers and pavers, and the United Equipment Company the Rex traveling water screens.

The Treadwell Engineering Company, Easton, Pa., announce the affiliation of Mark L. James as second vice president.

COMING MEETINGS

May 15-20—National Association of Purchasing Agents, seventh annual convention, also exposition at Exposition Park, Rochester, N. Y. H. R. Heydon, 19 Park Place, New York, is secretary.

May 25-26—American Society for Steel Treating, Sectional Meeting, Bureau of Mines Auditorium, Pittsburgh, Pa. D. W. McDowell, Jones & Laughlin Steel Company, local secretary.

June 5-9—American Foundrymen's Association annual convention and exhibition at Exposition Park, Rochester, N. Y. C. E. Hoyt, Marquette Bldg., 140 South Dearborn Street, Chicago, is secretary.

June 26-July 1—American Society for Testing Materials ,twenty-fifth annual meeting, Chalfonte-Hadden Hall Hotel, Atlantic City, N. J. C. L. Warwick, 1315 Spruce Street, Philadelphia, is secretary.

September 11-15—Association of Iron and Steel Electrical Engineers, 1922 convention at the new auditorium, Cleveland. John F. Kelly, Empire Bldg., Pittsburgh, is secretary.

The Blast Furnace and Steel Plant

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American Iron and Steel Institute Meeting

Fifteen Hundred Steel Men Attend the Twenty-first General Meeting—Valuable Technical Papers Read—Judge Gary's Address Features the Meeting.

THE twenty-first general meeting of the American Iron and Steel Institute was held at the Commodore Hotel, New York, on May 26. There were three sessions, the forenoon and afternoon sessions being devoted to the address of Judge Gary and the reading of a number of the technical papers. In the evening a banquet was held. The technical program presented at this meeting was very interesting. The papers read were as follows:

Address of the President, Elbert H. Gary, Chairman United States Steel Corporation, New York.

"The Development of the Iron and Steel Industry of Australia," David Baker, General Manager, The Broken Hill Proprietary Company, Newcastle, N. S. W., Australia.

"The Relation of the Doctor to the Steel Plant," Loyal A. Shoudy, Chief Surgeon, Bethlehem Steel Corporation, Bethlehem, Pa.

"Industrial Housing," C. L. Wooldridge, General Superintendent, Carnegie Land Company, Pittsburgh, Pa.

"The General Effect of Electrification of Steel Mills Upon Their Operation," Wilfred Sykes, Assistant to Operating Vice President, Steel & Tube Company of America, Chicago, Ill.

"The Importance of the Iron Ores of the Adirondack Region," Frank L. Nason, Geologist, West Haven, Conn.

"Methods of Using Fuel in Open Hearth Furnaces," W. C. Bulmer, Superintendent, Open Hearth Department, Ohio Works, Carnegie Steel Company, Youngstown, Ohio.

Part of the papers which were read are contained in this issue of THE BLAST FURNACE AND STEEL PLANT. Others will appear next month.

Judge Gary in his annual address said in part:

> Since the armistice of 1918 I have never spoken publicly without referring, though with brevity, to the signs of danger and depression, the possibility of demoralization and disaster as the result of the military cataclysm which for four years and more convulsed the world. We have not, I think, entirely passed from under the clouds of adversity. Certainly we are carrying hitherto unheard-of heavy governmental financial burdens. At best, these will not soon be fully discharged. To bear them gracefully and contentedly there must be not only forbearance, encouragement and assistance from every department of government up to the limit of propriety and justice, but there must also be entertained by every individual, consistently and constantly, a spirit of patience, pluck, energy, generosity, loyalty and charity fully up to his or her highest intelligence.
>
> Gentlemen here assembled, we must do our part. We must be fair and just, as loyal to the Government as we were during the war. We must treat others in such manner as to be entitled to their approval.
>
> Little need be said about the changed and changing business conditions for the better in the iron and steel industry. The facts and figures have been and are being published. The volume is large and increasing. The profits are not satisfactory, but few, if any, ought to be doing business at a loss, and we shall soon, I hope, settle down to a readjusted basis of prices and rates that is fair and reasonable and on a comparative parity. Let us be moderate in our demands. Profiteering will be more and more exposed and eliminated. I could if necessary refer to some outrages which still exist; but the general public, when correctly informed, is disposed to be just and it will not long overlook nor condone the exceptional glaring injustices that still obtain in prices and rates.
>
> Ever since the armistice was signed, when I have spoken it has been hopefully as to the long business future. I am still an optimist. And likewise are you. It is seen in your countenances. Big, even profitable, business has been ahead of us all these years, though it has been at times obscured. Now we seem to be nearer a realization. But every one in official or private life, employers and workmen, professionalists, merchants, financiers, mechanics, artisans, all, properly supported by our Government, may and will, as never before, utilize to the greatest advantage of our own people and others the existing and productive wealth of this great country.
>
> Optimism arises from opening one's eyes and ears and mind to the good things in life which a merciful and overruling Providence has bestowed. May all of us have sense to appreciate. Pity the chronic blind, deaf and foolish pessimist of the United States.
>
> The prosperity and welfare of all the people depend upon the enactment, the administration and the enforcement of law. It furnishes the fundamental distinction between human beings of today and the cave dwellers of the past.
>
> All fair-minded, right thinking men and women will agree that laws should be adopted, maintained and enforced strictly on the basis of equal opportunity and equal responsibility to every man, woman and child, wherever located and whatever the surrounding circumstances may be.
>
> Any law in its existence or administration that discriminates in favor of or against any individual, calling or location is essentially wrong and is injurious to the whole body politic. Any person who, for selfish reasons or as an advocate for another, insists upon a claim contrary to the one expressed is disloyal to the principles of our national scheme of government.

These principles should always be borne in mind by the executive, the legislative and the judicial departments of government; by the farmer, the merchant, the banker, the carrier, the manufacturer, the miner, the employer, the employe, the possessors of capital and the impecunious; and in these days particularly they should be constantly emphasized in the minds of all professionals—those who attempt to instruct or to minister to the wants of others.

I trust we of the iron and steel industry are conscious of our obligations to the laws of the land, to the general public and to our neighbors, those with whom we come into business contact. This should be our constant thought and study. This is a substantial part, nay, the controlling spirit of this Institute.

On the other hand, we have the right to insist that all others shall be required to conform to the same strict accountability; and that we shall receive the same protection and benefits that are accorded to others. As the prosperity of the country is vitally affected by the passage and administration of laws, even by the tinkering of legislation, so called, it is deemed appropriate to discuss before the business men of an important manufacturing industry some of the current proposed legislation, even though what we may say or think may have little influence.

There should be a commission of well paid, high minded, intelligent, competent and non-partisan appointees, authorized to ascertain and communicate the facts and figures, and their reports should be frequent so that, if deemed necessary, a change or amendment to the tariff laws could be made at any time Congress is in session.

The head of the great steel trust declared he welcomed fair laws for the regulation of industry or investigations that were honest and non-partisan. He said:

> The progress and prosperity of no nation can long endure if any single factor in economic life shall be especially favored or punished or exempted.

He therefore contended, he said, that trade unions and farmers' organizations should be subject to exactly the same kind of regulaton as industrial and commercial organizations.

Mr. Gary opposed immediate passage of soldier bonus, because "the load of taxation ought to be lightened, not increased." If passed at a later date he expressed strong approval of the sales tax as a method of raising the money.

Gas and Air Valves for Open Hearth Furnaces

Discussion of the Development of the Various Types of Valves for Which Each Inventor Claims Some Superiority.

By **WILLIAM C. BULMER,*** Superintendent,
Open Hearth and Bessemer Depts., Ohio Works, Carnegie Steel Company, Youngstown, Ohio

As the early metallurgist had little if any knowledge of gaseous fuels, it follows that he knew nothing of their application in his furnace. His experience was confined to the burning of solid fuels, such as wood and charcoal, and later to the organic deposits of the earth, of which coal, peat and lignite are examples. It is reasonable to assume that one of his very first problems included the regulation of temperature, which he solved by the use of the forced blast of the bellows. With the increase of his knowledge he learned that a further regulation of temperature was necessary, and we find him placing a movable cover over his chimney, or a damper or slide in the flue leading to it, whereby the passage of the waste gases to the atmosphere might be constricted at will or as his process demanded. He augmented this by the use of doors covering the opening through which he introduced his fuel, and over the pit from which the ash was removed. These contrivances not only permitted him to govern his temperature, but they also provided a means whereby he could control the character of the reactions taking place in his furnace, and we find him able to produce a reducing atmosphere, where one of an oxidizing nature did not suit his process.

In the development of the early blast furnace, it was discovered that large quantities of useful fuel, escaping from the top in the form of a gas, might be utilized for preheating the blast air for the furnace. This was accomplished by burning the gas in a chamber, through which the air was passed by means of cast iron pipes or conduits. From this grew the practice of burning the gas in a series of chambers and alternately passing the blast air through them before it entered the furnace. These inventions made possible the saving of more than one-half of the fuel otherwise necessary for the process.

The experiments of William and Frederick Siemens in the production of steel in reverberatory furnaces began as early as 1856. They found that they could not successfully obtain the results desired by the use of cold air in the combustion of their fuel, which led to the adoption of the regenerative principle characteristic of open hearth furnaces. Higher temperatures and an economy in the consumption of fuel were a natural consequence.

As all regenerative types of furnaces require a periodic reversal of the flow of gases through them, some mechanical agency must be employed to cause the change of direction. The simplest device for this purpose is the butterfly valve, and naturally it was the one first adopted. It served the purpose and would be the ideal contrivance if the material of which it is made did not become distorted through the expansion and contraction caused by the variation of temperature to which it is subjected. Its use for the regulation of the air has been more or less satisfactory, and in some cases it still survives as an adjunct to certain classes of air valves, but its application to the reversal of gas has not met with favor.

Apparently little effort was made towards the improvement of the early valves until the year 1889, when a water-cooled butterfly valve was installed at No. 2 open hearth plant of Carnegie, Phipps & Company at Homestead. The idea, of course, was to prevent distortion, but difficulty was encountered in keeping it watertight and it was replaced by a cast iron one of the dry class. This, in turn, gave way to the double-seated mushroom valve in 1900.

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*Abstract of paper presented before American Iron and Steel Institute, New York, May 26, 1922.

Minimum Resistance to Flow of Gases.

The chief requisites of a proper valve are an effective seal and an unrestricted passage. The choice of a valve requires most careful consideration, as upon the fulfillment of certain requirements depends the successful operation of the furnace. In order of importance we should consider, first, the valve having the minimum resistance to the flow of gases, combined with the least amount of leakage past the valve.

From investigation of installations now in use, it can be safely stated that the effective draft in the flue leading from the checkers will seldom be over 50 per cent of that found at the base of the stack. To determine the cause of draft failure, in the early stages of the campaign on furnaces at South Chicago, measurements were taken throughout the entire system of flues between the regenerative chambers and the stack. The gas valve was of a well known type used in conjunction with a butterfly air valve, and when measurements were taken in the flue on each side of these valves there was found to be a frictional loss amounting to 52 per cent of the stack draft. This is not at all an unusual condition, as installations have been found where the effective draft in the checker flues was only 30 per cent of that of the stack. In a heating furnace at South Chicago, on account of a difficulty existing in the draft, a considerably higher stack was built before an investigation of the conditions was made. As little improvement was found in the working of the furnace, a search was made to determine the cause of the trouble and it was found that the loss of draft, due to the valve and turns leading to and from it, amounted to 72 per cent of the stack draft. Obviously, in this case, the valves were altogether too small for the furnace. I have known of measurements being made at various plants on the draft loss due to the valves, and in no case have I found it to be less than 27 per cent, and this on a furnace where the valves were of rather ample size. In another investigation as to draft and pressure conditions existing through a gas valve, portions of the producer gas port of the valve were found to show a negative reading. This indicated only that the churning of the gas in passing through the valve formed zones of eddy currents which resulted in a partial vacuum. The moving of the pressure testing pipe across the area of the valve port would show readings varying from .4 in. to minus .1 in. water column. Needless to say, the actual area of flow through the port was considerably less than the total area, which of itself was too small for the amount of gas to be handled. Not only did the four right angle turns, necessitated in the flow of the gas out of the flue through the valve and back to the flue, cause serious frictional losses, but the impingement of the gas on the extending water seal was also a detrimental factor.

Resistance to flow through the valves has a very bad effect on the operation of any furnace, as the slowing up in the time of heats and the final shutting down of the furnace on account of the clogging of the air checkers are largely due to the lack of sufficient draft to pull the waste gases through the restricted opening. The dirt will accumulate in inverse proportion to the draft at the checkers, and only a sufficient pull at all times will insure a sharp working furnace. It is not difficult to decide, therefore, that the type of valve to choose is one that will permit of the draft at the checkers being as near to that of the stack as possible.

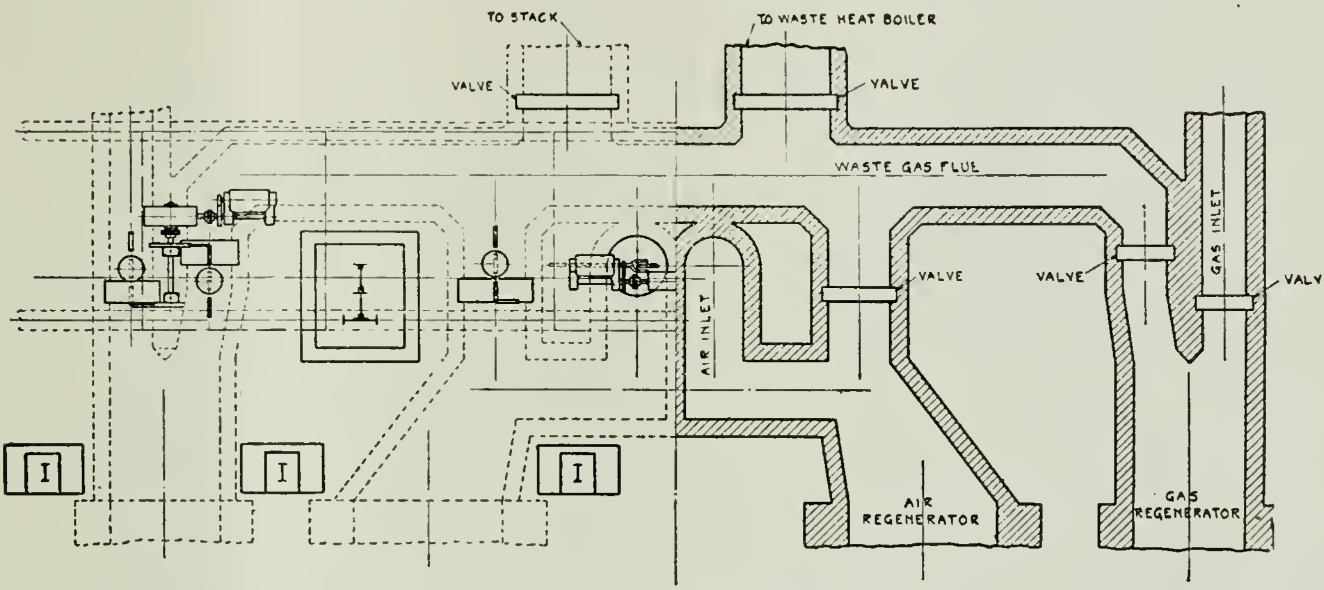

Fig. 1—Arrangement of flues for Knox Valves.

In addition to the valves, another factor which should be considered with reference to a free flow of the gases is the directness of flue passage with the shortest possible length, not only between the furnace and the stack, but also between the gas producers and the valves. Sharp turns in the flues, poorly designed valves, or a combination of both, will have a very detrimental effect upon the working of the gas producers, as it requires excessive pressure to drive the gas to the furnace, resulting in poor gas and improper producer operation. Many installations of restricted valves with poorly designed flues will be unable to properly procure a sufficient supply of good gas to operate to the best advantage with the adoption of the present day sharp working furnace, but in many cases this can be materially improved by the adoption of a valve having unrestricted passage.

Advantages of the One-Way Valve.

Valves may be divided into three groups, namely: one-day, two-way and four-way, depending upon the number of directions of gas or air passage through them. Those of the one-way group are the only ones which offer means of regulating the flow of gases to and from each checker chamber separately without additional equipment in the form of extra dampers or valves.

If a furnace is designed for proper distribution of the waste gases between the air and gas checkers, this distribution will not be maintained for long without proper valve regulation. The accumulation of dirt in the air checkers will add frictional resistance, which will decrease the proportionate amount of waste gases going through these checkers and the furnace will soon be thrown out of balance. By the use of a one-way valve, manipulation of the floor stands can be made to open the valve to any required degree, and at all times in the furnace campaign any desired proportion of the waste gases can be put through either of the chambers. The same regulation of the incoming gas can be made to offset the disadvantage of unequal port areas on either end of the furnace. This regulation should be particularly useful in a plant which does not run through Sundays. With only sufficient gas kept on the furnace during the Sunday shutdown to keep the furnace hot, the air chambers usually become much colder than the gas chambers and it is not until two or three days later that the temperature of the chambers is properly balanced. With a single-way valve installation, the regulation can be made such that practically all the waste gases, during the period in which the furnace is simply being kept warm, can be caused to go to the air chambers, thus keeping them up to a much better temperature than would otherwise be the case.

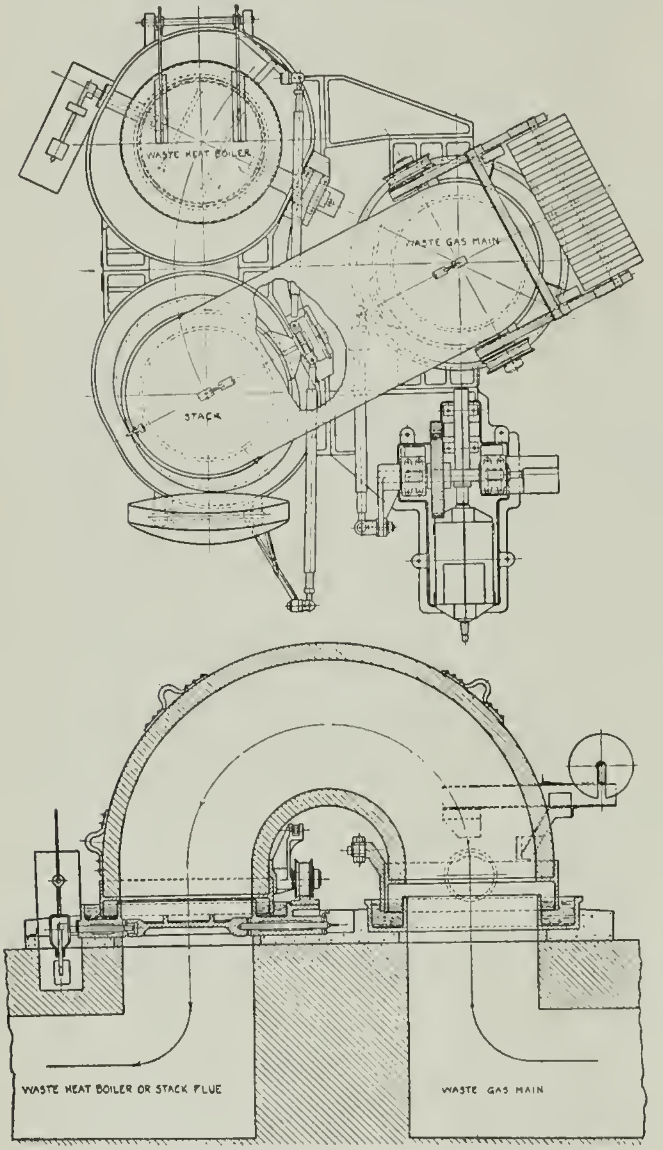

Fig. 2—The Blair valve.

Another advantage of a single-way valve is that it can be adapted to any desired flue layout and could often be readily installed to correct present difficulties, due to poor flue arrangement, with a poorly constructed valve that might be in use. For waste heat boiler work a valve giving straight line flow with a minimum of exposed water-cooling will give the best results. Not only does this type of valve insure higher waste gas temperature to the boilers, but because of their offering practically no resistance to the passage of the gases, they require less power for operating the boiler fan. The argument might be offered that where waste heat boilers are used, sufficient draft can always be obtained by the use of a sufficiently large fan, but this would be poor reasoning, for if between the stack and furnace ports certain frictional resistance can be tolerated, it is much better to have this resistance offered by a closer laying of checkers than by unnecessary resistance through the valves or with normal areas through the checker chamber. The less the resistance offered by the valves, the smaller the incoming and outgoing ports can be made, which will result in better combustion conditions.

Types and Classes of Valves.

Valves may be of the following types: slide or damper, butterfly, mushroom and movable hood. They may be classed as dry, refractory-lined, water-cooled and water-sealed.

The slide and butterfly types may be any of the classes or combination of classes, but the water seal is rarely applied to them. The mushroom type may be of any of the classes. The movable hood type is usually refractory-lined and water-sealed, although the refractory lining is sometimes omitted. In a general way the butterfly valve may be considered as a modified slide or damper, and we can state that the slide valve, of all those devised, offers the last obstruction to the passage of the gas through it. Invariably, in the other types, a change of direction in the path of the gas of from 90 degrees to 180 degrees, and in some cases as much as 360 degrees, occurs, and the friction losses are therefore bound to occur.

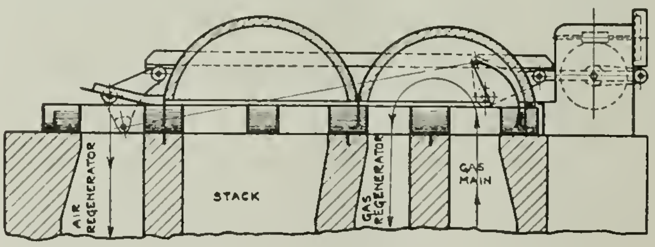

Fig. 3—The Isley valve.

In the dry class no attempt is made to cool the casting or plates of which the valve or its seat is made. The slide and butterfly are frequently of this character.

The refractory-lined valves are confined mostly to the slide, mushroom and movable hood types, although nearly all have the surrounding hood, where such is employed, lined with brick. Refractory linings are hard to hold in place because of the jar that accompanies the reversal, and no matter how tightly wedged when put in service the lining will eventually loosen and fall out.

The water-cooled valves embrace the slide, butterfly and mushroom types. They have the principal parts, including the seat, filled with moving water, whereby an even temperature within the member is maintained and distortion from expansion and contraction prevented. They are not always reliable in this respect and are particularly likely to fail after a short time when made of cast iron.

About the year 1914, experiments were begun with a water-cooled damper valve made of rolled steel plate and at the present time it is possible to procure a welded steel plate valve working on an inclined water-cooled seat, each having machined surfaces where contact is made, that will give a minimum amount of leakage and is so constructed that any expansion or construction that might take place does not tend to distort the valve and destroy the seal. Some trouble was experienced with the accumulation of a carbonaceous material on the face of the valve which might tend to cause leakage, but with the present valve the trouble has been so slight that it is being given very little consideration. The adoption of a refractory surface, where the valve is exposed to the producer gas, will materially aid in eliminating any slight trouble that might be caused from this source.

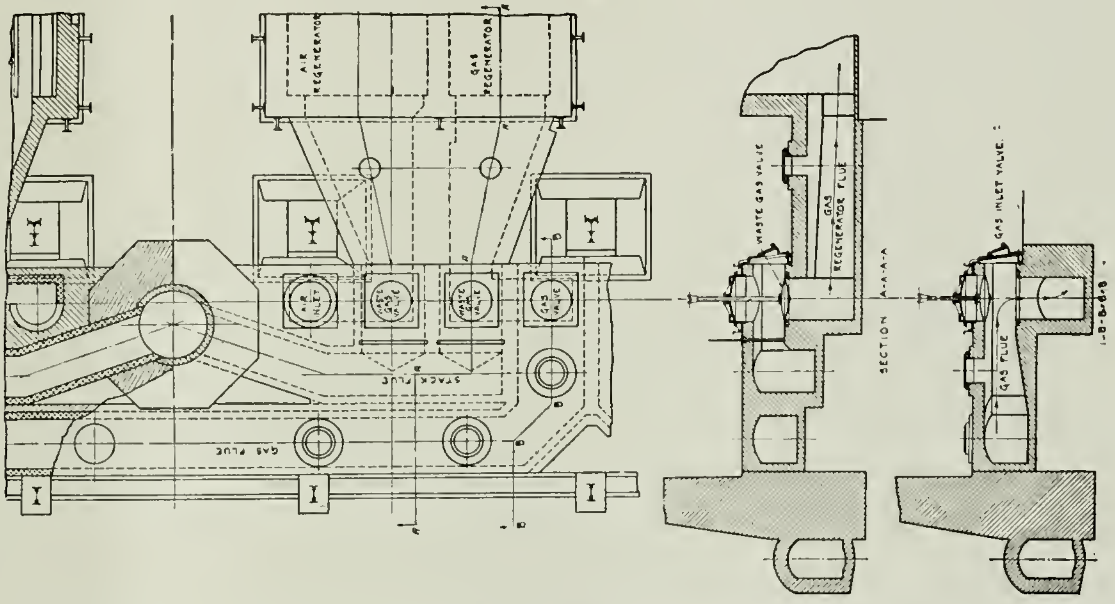

Fig. 4—Reversing valves and flue arrangement—Pennsylvania Steel Company, Steelton, Pa., 1910.

Water-sealed valves provide the most perfect seal that has as yet been devised and can be used effectively with the mushroom or the movable hood. In each case a projection of the valve is plunged into a basin of water of sufficient depth so that the liquid column will more than balance the difference of pressure within the conduit and the atmosphere or adjacent passageway. The glaring fault of this class of valve lies in the water evaporation that takes place from the basin; the passing hot gas picks up the vapor and is cooled to an appreciable extent. There is also more or less water splashed into the gas flues at each reversal. This not only must be evaporated, but coming in contact with the brickwork of the flue causes deterioration. At the Gary works of the Illinois Steel Company, on some of their stationary producer gas furnaces, the change from a valve having exposed water and exposed water-cooled parts to one having a minimum amount of exposed cooling surface, resulted in an increase of temperature in the waste gases going to the boilers of approximately 180 degrees. This temperature difference checks up very well with the usual temperature drop found through the ordinary types of valves which offer a large amount of exposed cooling surface, and in one investigation I found the temperature to show a difference of 240 degrees. A similar change of valves at Wierton has resulted in their increasing the waste heat boiler output from 58 per cent to 78 per cent of rating. Wierton is getting this rating from their boilers on a low coal consumption, which, when their furnaces are working properly, is in the neighborhood of 450 pounds per ton of ingots.

Another objection to the use of a valve having a water-sealed seat has been that it is always liable to leakage in portions that are hidden from the view of the furnacemen, and it is only when the effect upon the working of the furnace is noted that inspection, which in most cases is difficult, proves that the trouble is due to a crack in the casting, and it not infrequently happens that a negative pressure will cause a portion of the water to syphon from the basin into the flue. The substitution of welded steel plate seats for cast iron seats has to a great extent eliminated the trouble due to leakage, but the immersion of the valve into the water when the seal is made will remain a constant factor in the splashing of water over the edge of the seat and into the flues. The brick walls that form the flues and support the valve suffer from the effect of this moisture and the resultant weakening of the joints often causes leakage of gas from the gas passage into the waste gas flue, which often continues for a considerable length of time before becoming sufficiently bad to cause detection. The impact upon the seating of certain types of water-sealed valves is an added source of destruction to the seat, and not only do you have a serious loss, due to leakage of water into the flues, but in most cases it is necessary to stop the operation of the furnace until the seat can be replaced.

An added security is provided against gas leakage past the valve in one make in which the flues are completely separated by means of a brick-lined tube, acting on the same principle as a switch in a railroad track, whereby the flues are connected as desired and the change in the flow of gas controlled. The water in connection with this valve is of comparatively small area, open to inspection at all times.

For moving valves every known method has been applied, including hand power, hydraulic, pneumatic and steam cylinders, and electric motor. The latter method is no doubt the most satisfactory, and its popularity will increase in the future. Whatever the mechanism employed, it should be of a sturdy character and able to withstand the strains that are put upon it.

The theoretical relation of the areas of gas and air valves and openings into the furnace has been discussed by numerous authors and for those who may be interested in this phase of the subject, reference is made to the paper on "The Principles of Open Hearth Furnace Design," by Charles H. F. Bagley,* and also to the paper on "The Basic Open Hearth Process," by Mr. F. H. Toy,† in which he states that practical experience has demonstrated that an air valve area of one square foot per ten tons of furnace capacity is adequate.

Much thought has been given to the development of a satisfactory water-cooled valve and seat, and to one having a perfect seal, but it would appear that with the exception of two of recent invention, i. e., one in which one end of a section of flue swings through an arc of a circle connecting adjacent flues, and the welded steel damper type having an inclined water-cooled seat with machined working surfaces, none measure up to the requirements we have stated for an ideal valve. Too much weight should not be given in the choice of a valve to the first cost, providing satisfactory operating conditions in all respects can be attained.

The water-cooled slide with inclined seat comes nearest to the perfection we are seeking. Its durable mechanical construction, including sturdy manipulating devices, all of which is easily accessible for repairs, combined with straight line flue passages, least heat losses, independent control of flow for each chamber, minimum leakage, adaptability to local conditions, small space required, minimum loss of fuel at time of reversal and low maintenance cost, recommends it to our serious consideration.

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*Journal of the Iron and Steel Institute, Vol. II. pp. 289-303.

†Year Book, American Iron & Steel Institute, 1920, pp. 319-362.

The General Effect of Electrification on The Operation of Steel Mills

Some Interesting Figures on the Operation of the Mills at the Mark Plant Are Included—Writer Believes Electric Power Is More Economical Than Steam Power.

By WILFRED SYKES
Assistant to the Operating Vice President, The Steel & Tube Company of America,
Chicago, Ill.

THE reason for electrification is fundamentally due to certain inherent characteristics of the generation, distribution and utilization of electricity. Electrical generating stations use prime movers of the most economical type known today and of such size as to give the best operating results, independently of the size or characteristics required for any particular mill or other consumer of power. The combination of generating units in service depends only upon the combined load of all the mills that may be running and the available capacity can be varied rapidly to supply the demand for a greater or a lesser output and still maintain a high operating efficiency.

Frequently we have a choice as prime movers of either internal combustion engines, using blast furnace gas, or of steam turbines. The former, while having a better fuel economy, are limited by constructional difficulties to sizes of not larger than 3,000 to 4,000 hp, so that a large plant requires a great many individual generating units. The steam turbine can be built in any size that is required for even our largest plants and the limit of output of a single unit has not yet been reached. The first cost of a gas engine driven station is at least twice as much as a modern steam station and this frequently is sufficient to offset the better economy. Continual improvements are being made in the design of steam stations which tend to reduce this difference in economy, and the situation today is that the difference in the number of heat units required in the fuel under average operating conditions probably does not exceed about 15 per cent. This is the overall efficiency from the fuel to the switchboard. The result of this freedom of choice of prime movers and the facility with which different combinations of machines can be run, to take care of varying operating conditions, makes possible a very much better utilization of the energy in the fuel than is possible with any type of prime mover driving the mill direct.

Another advantage of centralizing the power equipment is that, due to the diversity of the mill loads, the average that has to be carried by the central station is very much less than the summation of the loads that occur on the individual consuming units, and the fluctuations of load are less, so that the prime movers can be run at more nearly their most economical output.

The conversion of the output of the prime mover into electricity is accomplished with a loss that seldom exceeds 5 per cent with modern equipment.

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*Abstract of paper presented before American Iron and Steel Institute, Spring Meeting, May 26, 1922, New York City.

Perhaps the greatest economy of electric drive is due to the small loss with which this form of power can be distributed and the fact that the loss varies with the load so that the lines can be kept charged ready to supply power as demanded and loss only occurs when power is actually being used. Even at full load the loss in the lines seldom exceeds one or two per cent. If we contrast this with steam distribution, the saving is very obvious. Anyone interested in making up steam costs in a mill knows that, even after making what appears to be very liberal allowances for the consumption of the different engines based on the output of the mill, there remains a very large amount of steam not accounted for; and I think it would not be an overstatement to say that we can seldom account for more than about 50 per cent of the steam generated, consequently the difference must be prorated over the different mills. It is therefore very misleading to talk of any engine consuming so many pounds of steam per horse-power or per ton of steel rolled, unless we take into consideration this factor since what we are really interested in is the amount of fuel used as gas or coal to roll a ton of steel. This is a condition with which every mill engineer is familiar and even the best laid out and operated plants do not appear to be able to avoid it. With modern engine drives, quite good efficiencies are obtained under test conditions although, of course, not as good as can be gotten in a properly laid out central power station.

To convert the electrical energy to mechanical work we must use motors. The efficiency of a continuously running motor under the varying conditions of load will usually average well over 90 per cent. In the case of a reversing mill, which involves first the conversion of electricity from one form to another and then into mechanical work as well as providing for equalization of the peak loads, the overall efficiency from the switchboard to the mill coupling will run over 75 per cent.

In any discussion of economy we must be careful to distinguish between theoretical figures and actual operating results, as what we are interested in is the overall efficiency from the energy in our gas or coal to the mill coupling during a month's or a year's operation and the only teacher of any value is experience. The best measure is our power cost per ton of material shipped. Complete electrically driven mills show decided advantages when this measuring stick is applied to the question.

As a matter of interest, I am giving a few figures of two reversing mills in our plant, one being the reversing blooming mill and the other the reversing universal plate mill. The former rolls ingots (20 in. x 22 in., weighing 7,300 lbs.) to blooms averaging about 6 in. x 8 in. for the billet mill, and ingots (16 in. x 38 in., weighing 10,500 lbs.) to slabs for the plate mill. The plate mill rolls the slabs from the bloomer to skelp for the pipe mills, a typical range of which is given later in this paper.

Closely connected with the subject of economy is the question of mill layout. The facility with which electricity can be distributed relieves us of the necessity of considering power distribution and mills can be arranged in the best possible manner for operation without having to face any disabilities on the score of power economy.

POWER CONSUMPTION OF REVERSING MILLS, STEEL & TUBE COMPANY OF AMERICA FOR 1920

Kind of mill	Gross Tons of Ingots or Slabs Rolled	K.W. Hours per Ton, Main Drive Only	Power Cost per Ton, Main Drive Only
Blooming mill ..	444,510	16.2	17.8 censt
Plate mill	191,524	31.9	35.1 cents

Average coal cost per ton at boiler house during year = $5.07.

Gas charged for at coal price on basis of equivalent evaporation.

To sum up, with a central station we manufacture our power wholesale and through a very cheap distributing system we deliver it to the consumer as required. If the mill does not require power, it does not have any losses to take care of. It is very much the same situation as exists in the commercial field. If we had poor distributing facilities for our commodities, it would be necessary to have a great many plants scattered over the country to take care of local demands, some of which would be busy and some idle with a consequent low average efficiency. As it is, we build a few plants in favorably situated localities and ship to the consuming points as required. We pay freight only as we ship. The demand of one locality frequently balances a lack of demand from another, so that our plant can be run at a good average load and efficiency.

The statement is sometimes made that electric drive is more expensive than a steam drive. I doubt very much if this is really so when a true comparison is made of all the factors that must be taken into consideration, such as boiler plants, steam distribution, water distribution, sewers and many other items that affect the total cost of the plant. Too frequently, in discussing this question, comparisons neglect important items which, while difficult to estimate, must be considered.

The rapid extension of steel-making and finishing capacity in recent years would indicate that in the immediate future the problem will be not so much extensions, as a rehabilitation of the older plants to enable them to operate with such efficiency as to be competitive, and this will require careful consideration of electrification as a means to this end.

Before leaving this phase of the subject, it is perhaps well to point out that the necessity of generating electricity for auxiliary purposes, regarding which no one questions the advantages, requires stations of substantial output. The following table illustrates this point and shows the power used for main drives and for auxiliary purposes at the Mark Plant during the year 1920. It will be seen that if the mills were driven by engines, a large proportion of the total power would have had to be electrical in any case.

Mill	Main Drive Only, K.W. Hours	Auxiliary Purposes, K.W. Hours
Blooming mill	7,061,000	5,040,000
Plate mill	6,111,000	2,967,000
Billet mill	2,920,000	1,890,000
Skelp mill	7,700,000	
	23,792,000	9,897,000

Total power generated	53,428,000 K.W. Hours	
Consumed, main drives	23,792,000 K.W. Hours	44½%
Consumed, mill auxiliaries....	9,997,000 K.W. Hours	18½%
Consumed, other parts of Steel and Coke Plant............	19,639,000 K.W. Hours	37 %

Production.

Leaving the general characteristics of electrification I will endeavor to answer some of the more important questions that interest the executive and operator. The first question that is asked regarding any method of driving our mills is whether it will enable us to get the desired output? This is not only a question of the amount of power available but of the characteristics of the driving unit and the subject must be considered in relation to the different types of mills.

Continuously Running Mills.

In the case of a mill running continuously in one direction, there are practically only two points to be considered. The first is the power, the second is the speed characteristic. As far as power is concerned, any output required by our mills presents no unsolved problem to the motor designer. Very much larger motors than any individual mill is likely to need have already been built. I believe the highest rating of any machine driving a continuously running mill is that of the motor driving the 160 in. plate mill at Gary, Indiana. This motor is nominally rated at 7,000 hp, but to meet the particular specifications, it actually has a continuous capacity of about 9,000 hp. In operation this machine very frequently carries peak loads up to about 18,000 to 20,000 hp. The largest electric motor that has been built to date has a continuous rating of 22,500 hp or more than twice the capacity of the 160 in. plate mill motor and there is no particular reason why larger machines could not be constructed if there was any demand for them. As far as power is concerned, it is only a question of determining how large the motor should be. When we first started to electrify mills, very little data was available that would enable us to determine the proper characteristics. When it was attempted to translate indicator cards from existing engines into terms of motor output it was frequently lost sight of that the speed characteristics of engines and motors are very different and the indicated horsepower readings could be very deceptive, especially if the inter-relation of engine output, speed, and fly-wheel action were not carefully analyzed. Consequently, in the early days some mistakes were made, although on the whole it is surprising how few. Information that could be gathered from mills as to production was frequently fragmentary and it was early evident that if satisfactory results were to be obtained the electrical engineer would have to study mill operation and conduct such tests as would enable him to analyze the requirements. A great deal of work was necessary to enable this to be done, but real progress was not made until the manufacturer could tell the mill man that he could supply an equipment that would roll so many tons of finished material under defined conditions. This was something that was perfectly definite and subject to ready tests. It involved not only motor design but also cooperation between the electrical manufacturer and the purchaser on the subject of the type of connections between the motor and the mill, and the size of the fly-wheel and its location. Today, there are so many installations in operation and so much accumulated experience that the problem is comparatively simple and it is mainly a question of deciding the output required, keeping in view the possibilities of electrc drive and of improvements of mills and auxiliaries which enable material to be handled more expeditously. In this respect it is fortunate that the electric motor has a practically constant high efficiency over a very large range of load, varying usually not more than ½ to 1 per cent from one-half to full load, and also that the power station is so flexible that, if a machine is too large for the immediate requirements, the net effect on efficiency is practically negligible. It frequently happens that it is difficult to definitely specify operating conditions or that conditions will change after the mill has been installed and it has been my experience that it is wise to be liberal in choosing the size of motor, as the only disadvantage in doing so is a slight extra outlay which, in relation to the total mill cost, is trifling.

Regarding the speed characteristics, the ordinary motor tends to run at a practically constant speed independently of the load. Where a fly-wheel is used, the object is to assist the motor in carrying short time peak loads. For instance, in the case of a plate mill, the early passes may require four to five times the power of the motor for a fraction of a second. It can be arranged very readily that the motor will take a certain proportion and the fly-wheel supply the remainder. When the passes become longer, the peaks are reduced and the motor then carries a greater proportion of the load. By the proper inter-action of the motor and the fly-wheel, an economical balance is arrived at. The speed characteristics of the motor are usually varied by means of the control equipment and they can be readily adjusted to suit individual operating conditions. In the case of mills where the passes are long, the fly-wheels are of less value and it is frequently desirable that the speed remain practically constant, which is the inherent characteristic of the motor. We therefore have the possibility of either maintaining the speed constant within two or three per cent or of regulating it to give the best operating results, depending on the load condition. Sometimes the characteristic of constant speed enables us to obtain greater output as compared with an engine which usually does not hold its speed so well under heavy load; and in some cases that have come to my attention, it has been stated that the mills have an output of 5 to 10 per cent greater when electrically driven. In this connection it should not be lost sight of that the ordinary mill motor can carry double load for short periods without any particular sacrifice of efficiency or any great change of speed. Of course we want to run the mill as fast as the metal can be properly rolled and frequently the speed at which the metal can be entered into the rolls is the controlling feature, so it is obvious that the closer we can hold the average operating speed to this maximum, the greater will be the output.

Reversing Mills.

There has been more discussion regarding the motor driven reversing mill in comparison with the steam engine drive than of any other type and this is quite natural, as the motor is an invader in the field for which the engine seems to be particularly well adapted. Quickness of maneuvering and ease of speed control is of the utmost importance for a successful drive. This will be appreciated when it is realized what a comparatively small percentage of the time the metal is in the rolls. An analysis made of a number of steam and motor driven mills shows that in the case of a blooming mill operating rapidly, the metal is in the rolls about 30 to 40 per cent of the total time of rolling and from 60 to 70 per cent of the time is required to handle the steel. A casual observation of the mill does not reveal this, but it is surprising how closely well operated mills approximate to the same figures. There has been a good deal of discussion regarding the ability of the motor driven mill to turn out tonnage and if an analysis is not made of the operation, one can be readily deceived when observing steam and motor driven mills in operation. A motor driven mill appears to maneuver slowly but a closer observation shows that it is operated in a different way than the engine driven mill, due to the fact that its speed can be more accurately controlled. Observation of operation frequently leaves the impression that the motor driven mill is not doing much work, due to the absence of noise or other indications of action. Actual records, however, show that the motor can give a good account of itself. I am quoting a few figures from different mills which indicate the output that can be obtained in practice. I do not believe that these represent, in any way, the limits of a motor driven mill, as development is still taking place which enables the equipment to operate quicker and more efficiently, and I am sure that very much higher figures can be obtained than the ones I am quoting. I have not attempted to collect figures from all electrically driven reversing mills but am giving a few that have come to my attention. Possibly engineers from other plants that have electrically driven reversing mills have figures better than those I am quoting, but, at any rate, they will indicate what has been done.

At the plant of the Trumbull Steel Company, Warren, Ohio, there is installed a 36 in. blooming mill which rolls ingots 20 in. x 22 in., weighing 6,700 pounds to 6¾ in x 6¾ in. blooms in 13 passes. This mill has rolled 60 of these ingots in one hour and the operators feel that this figure can be improved.

Perhaps a better indication of the speed with which a motor can be handled is given by the machine driving the roughing stand of the 84 in. tandem plate mill of the Brier Hill Steel Company. The following figures show a 12-hour and 24-hour record. It will be seen that there is very little difference between the 12-hour and 24-hour figures:

ROLLING RECORDS OF THE 84 IN. TANDEM PLATE MILL OF THE BRIER HILL STEEL CO.

	12 Hours	24 Hours
Number of slabs	1,659	3,270
Number of passes in roughing mill	7	...
Total charged weight, tons	373	716
Total finished weight, tons	315	518
Maximum number of slabs for one hour	220	...
Finished tons of 10, 11, 12 and 14 gauge U. S. Standard	23	71
Finished tons of 8 and 9 gauge	13	435
Finished tons of 3/16 inch, No. 10 gauge	26	6
Finished tons of ¼ inch and heavier	253	6

It will be seen that this mill averages, over a 12-hour period, about 16 passes a minute or less than 4 seconds per pass, which takes in all delays due to any cause. This mill has been in operation since September, 1919, and the performance has progressively improved as the men became familiar with the best methods of operation.

A third illustration, taken at our own plant, is that of our universal plate mill which has rolls 30 in. in diameter and can roll universal plate up to about 46 in. wide. It is used for rolling skelp for our pipe mills and the material is, on an average, small for this size of mill. During the month of March, 1920, this mill turned out 23,014 gross tons of material and, as a matter of interest, I am giving details of how this was made up, from which it will be seen that the gauge was fairly light and the width not the best to secure maximum tonnage.

UNIVERSAL PLATE MILL PRODUCTION, MARCH, 1920

Sizes Rolled					
Width Inches	Thickness, Inches	Length Feet	Product Gross Tons	Slab Sizes, Inches	Slab Weights, Pounds
12	.375	Various	12	11¾x4	Various
15	.250	18′–19′	1,598	15 x4½	1,480–1,240
15	.360	18′–19′	72	15 x5½	1,790–1,440
18½	.310	18′–19′	510	18¾x5½	2,270–1,905
18½	.385	18′–19′	145	18¾x6	2,480–1,990
22	.290	19′–20′	1,003	22¼x5½	2,650–2,220
22	.437	18′ 6″–19′	25	22¼x5½	2,630–1,975
22¼	.255	19′–19′ 6″	174	22½x5	2,320–1,940
23½	.245	19′–20′	288	23¾x4½	2,390–2,000
23½	.285	19′–20′	2,816	23¾x5½	2,780–2,340
23½	.345	19′–20′	4,149	23¾x5½	2,820–2,270
25	.465	18′ 6″–19′	25	25½x6	3,165–2,385
28¾	.285	19′–20′	953	29¼x4½	2,850–2,290
28¾	.290	19′–20′	774	29¼x4½	2,900–2,325
28¾	.295	19′–19′ 6″	125	29¼x4½	2,920–2,350
28¾	.320	19′–20′	3,302	29¼x5	3,210–2,600
28¾	.330	19′–20′	1,038	29¼x5	3,280–2,630
28¾	.365	19′–20′	931	29¼x4½	2,925–2,210
28¼	.437	9′–11¾″	27	28¾x5	3,110–2,660
28½	.585	18′–18′ 6″	132	29 x5½	3,330–2,190
32¾	.375	Various	74	33¼x5	Various
35½	.290	19′–20′	872	36½x5½	4,280–3,580
35½	.320	19′–20′	1,056	36½x4½	3,180–2,390
35½	.360	19′–20′	1,837	36½x5½	4,380–3,580
35½	.365	19′–20′	319	36½x5½	4,380–3,580
35½	.450	19′–20′	506	36½x5½	4,500–3,430
42¾	.345	19′–20′	251	36x5–44½	2,160

Total gross tons rolled	23,014	
Total hours worked	648	
Total hours delay	79	
Actual hours worked	569	
Total slabs rolled	21,100	
Good product	94.00	Per Cent.
Maximum day	1,101	Gross Tons
Minimum day	732	Gross Tons

It will also be seen that the delays were appreciable, which was due to the necessity of waiting for steel at times, roll changing, and minor troubles. We do not feel that this represents the limit of capacity of this mill and if necessary it could probably be boosted up to close to 30,000 tons per month by the addition of more heating furnace capacity and perhaps the elimination of some of the sizes which are entirely too small for a mill of this size.

These examples will give an indication of what is actually being done with the reversing mills that have already been installed. It has been my experience that factors outside of type of drive have in general limited tonnage. Much greater outputs can be obtained if necessary.

Delays.

If we are satisfied with the possibility of rolling a desired tonnage, the next question is whether the equipment will operate continuously or at least with no more delay than encountered with steam drive. Here again the best answer is experience and in the following I am quoting figures from one or two mills which show the actual results obtained. The first electrically driven reversing drive to be installed in the United States was that of the 30 in. universal plate mill in the South Chicago Plant of the Illinois Steel Company, which was put in operation in 1907. It was designed about the same time as the first equipment in Europe and went into operation a few months later. It must be appreciated that the electrical engineer was attempting to solve an entirely new problem with very little data and no experience, and later developments have shown that many of its constructional details could be materially improved. However, the history of this pioneer installation is of interest as it illustrates that even with an entirely new problem the time lost due to changes or breakdowns has not been serious. The major delays of this mill have been as follows:

November 10, 1907—Mill shut down for one week to correct armature cross connections.

October 14, 1908—Mill shut down to try out spare generator armature which had been purchased.

September 12, 1909—Change of generator armature due to grounded coils.

October 24, 1909—Generator armature changed due to some bars becoming unsoldered.

A novel design of generator was tried out in this installation which has not been used in subsequent jobs; this accounts for the particular troubles that caused the above delays. In 1911 there was a delay of a few hours caused by a slight short circuit on the commutator of one of the roll motors and in 1913 the mill was down for approximately 72 hours due to a grounded motor coil. In 1917 the generator armature was changed on account of a ground. The total of all delays, including those occurring during the development period, is approximately 525 hours out of about 100,000 hours that this mill has been operating, which I think is very creditable when it is borne in mind that it was a pioneer installation and was built at the time when the electrical engineer had not had the experience in building large equipments for steel mills that he has today. It might be mentioned that in 1920, after this mill had been in operation 13 years, no delays were charged against the drive, although the mill rolled in this year 20 per cent more than in any other year in the first ten years of its life.

In March, 1913, The Steel Company of Canada put in operation a 34 in. electrically driven blooming mill. This equipment embodied a number of important changes from the general design used for the Illinois Steel Company's mill and some control features which at that time were novel. A few days were lost, when the mill was first started up, in making a number of changes in the control. No particular effort was made to save time, as at that period the output of the mill was not urgently required. During the last six years the total delay charged by the blooming mill department against this equipment has been about 12 hours and a detailed analysis of these figures shows that only about two hours have been due to delays caused by the equipment itself being down for any reason. These delays were made up of a few minutes at a time required to change a contact on a switch or some such minor matter, the remainder of the time lost was due to such causes as interrupted power supply, etc.

Another example is the 35 in. blooming mill at Mark Plant. This mill was put in operation in April, 1918, and has run continuously to date. The total delay charged to the equipment is about 12 hours, the major part of this being due to interruption of power supply, which occurred when sand got into the boiler feed pumps and made it necessary to cut down station output until the difficulty could be corrected. Only a small part of the delays have really been due to the inability of the drive to operate the mill, perhaps not more than an hour or so. Such times that the mill has had to be shut down for electrical troubles have been made up of periods of a few minutes at a time for correction of minor difficulties involving adjustment of control equipment.

The examples I have cited I think are typical of what can be expected with reasonable operation and if accidents do not occur. Of course in the development of such equipments troubles have occurred which have been eliminated in later designs. Most of these troubles have been of a minor nature and the tendency has been towards simplification and so arranging the layout that an oversight or carelessness on the part of the attendants would not cause serious difficulties. However, accidents will happen in all plants and as an illustration I might mention some troubles we had with our plate mill drive. On one occasion it was found that the blowing equipment, upon which the cooling of the reversing motor depends, was not operating. This was not discovered until the motor had become very hot, so hot in fact that the solder from some of the connections flowed. In later equipments, by simple means, provision has been made so that the motor cannot be operated if the blower is not delivering air to it. Nothing occurred immediately following this overheating, but about a year later one of the armature coils broke down and an examination of the machine showed that the insulation had been seriously injured by overheating. Temporary repairs were made which caused a delay of about 24 hours but a few weeks later another armature coil failed and it was decided that it would be wise to shut the mill down long enough to entirely rewind the armature, as it was felt that the winding had been so injured that more or less trouble could be expected from it, if this was not done. The motor was therefore put out of service and the armature completely rewound, the time required for the different operations being as follows:

Disconnecting from the mill and removing armature from motor	12 hours
Stripping old coils and preparation for rewinding	34 hours
Rewinding	50 hours
Reassembling the machine	16 hours
Drying, varnishing and baking the armature	96 hours
Total	208 hours

As a precautionary measure it was decided not to start the machine until it had been thoroughly dried out and we were sure it was in as good condition as when originally installed. Facilities for drying and baking the armature, such as manufacturers have, were not available and it was necessary to experiment somewhat to find out the best way to do this. At least 60 hours could be saved, if such a mishap occurred again. If a spare armature had been available, the delay would not have exceeded 24 hours. This represents about as serious a failure as is likely to occur and I am giving its history so that some idea can be formed of what a really bad breakdown of such an equipment means in the way of delay.

Operating Labor.

A factor in which our operators are particularly interested is operating labor. Most mills feel that their larger and more important drives, such as reversing mills, should have an attendant present to watch them, mainly as a precautionary measure. In the case of continuously running mills, there has been enough experience to show that this is not necessary and now it is customary for one man to inspect a number of machines and to take the usual meter readings for the mill records. When an operator is employed continuously to look after a drive, the usual practice is to put substation equipment under his control, as it is generally convenient to install converting apparatus in proximity to the main drive. These men have very little to do outside of occasionally looking over the machines and taking meter readings. The actual work in attending to a reversing blooming mill drive, for instance, I do not believe would exceed one hour per day. At the Mark Plant the blooming mill has been charged, for the years 1918, 1919, 1920 and 1921, an average of $393.00 per month. In the case of the reversing mill of The Steel Company of Canada, from 1913 to 1919, the average has been about $250.00 per month. The difference is mainly due to the fact that the figures for the former cover the period of highest wages in the mills.

Maintenance and Repairs.

Electrical machinery requires maintenance as well as any other equipment. With intelligent electrical superintendents most of the expenditure is of a precautionary nature and repairs due to breakdowns become a very small item. As an illustration of the maintenance and repairs on reversing drives, the experience of The Steel and Tube Company of America can be cited. For the four years, 1918, 1919, 1920 and 1921, the maintenance and repairs for the reversing blooming mill drive averaged $184.00 per year. In the case of the reversing plate mill drive previously referred to, the ordinary maintenance and repairs have averaged about $173.00 per year and the expenses in connection with the failure and complete rewinding of the armature totaled about $6,530.00. The maintenance of the blooming mill of The Steel Company of Canada has averaged since it was installed, for all purposes, about $1,280.00 per year. This higher cost compared with that at the Mark Plant is due mainly to the smaller size of the plant and a part of the difference may be ascribed to improved design of the later equipment. The supplies for operating these two blooming mills have averaged in each plant about $50.00 per month. These figures give an idea of what can be expected in the case of reversing mills. In the case of continuously running mills, the expenditures vary considerably, some mills paying practically no attention to their equipment and others carefully clean and revarnish their machines at intervals. In going over the figures of plants where freedom from breakdown is characteristic, it would seem that for motors from 2,000 to 3,000 hp we should spend perhaps $200.00 to $250.00 per year to keep them in condition. The cost will vary somewhat with the number of equipments the force has to look after, as with a larger plant the cost per machine will average less than in a smaller mill. Before leaving this phase of the subject I would like to quote a statement of the electrical engineer of the Illinois Steel Company regarding the physical condition of their reversing mill which, as previously stated, has been in operation since 1907. The commutators of the reversing motors show about 1/16 in. wear and the commutators of the generators show a wear of about 1/16 in. for each five years of service. This would indicate a life for the commutator of the motor of about 180 years and for the generator about 60 years. The windings are in apparently about as good a condition as when first installed. At the end of 10 years some wear of the motor generator bearings was noticeable and as an insurance, spares were purchased, but to date have not been installed, as in the last five years there has been no appreciable wear. The original motor bearings are in use and apparently will last indefinitely. Another example illustrative of the long life of electrical equipment when given good care which came to my notice, is the case of the 2,000 hp motors driving the light rail mill at South Chicago, Illinois. These machines were installed in 1906 and after about 14 years of service the Steel Company thought that perhaps it would be a good precaution to rewind them. A careful inspection by the manufacturer revealed no apparent deterioration and the recommendation was not to disturb them. These experiences indicate what can be expected with carefully operated plants.

In the foregoing I have given a few examples that will indicate to those whose duties do not bring them in close contact with electrical equipment what can be expected. It should be borne in mind that manufacturers have profited by their accumulated experience and many possible sources of troubles have been eliminated in recent installations. Another factor that will tend to secure even better results in the future is that a body of intelligent electrical engineers and attendants has been built up by our technical and trade schools, as well as by the principal manufacturers, from which our mills can draw good men. The electrician of the early development period was often very expert in making repairs but did little to avoid them. Today men are available who have been trained to avoid troubles.

Due to the many ways in which power problems can be solved electrically it is natural that frequently a difference of opinion exists as to the best way to handle particular requirements. In many of the cases, either one of a number of schemes will give entire satisfaction. In other cases, perhaps there is a best scheme, but other layouts are capable of satisfactory operation although not inherently as good as the best. In the following I am endeavoring to make what seems to me to be a fair statement as to the present state of the art, which might perhaps act as a guide to those having to make decisions on equipments and who are not familiar with engineering details. I am not attempting to give the reasons for these statements as it would lead into too long a controversial paper.

Power Equipment.

In building a modern plant we have the choice, in most localities, of either purchasing power from a Public Utilities Company or of building our own power plant. When we have sources of heat that would otherwise be wasted, this is usually sufficient reason for building our own plant. Public utilities, however, in many cases can make rates and give assurance of continuity of supply which make their power attractive.

Any modern power plant would only be built with alternating current units, as direct current involves too much expense for the distribution of large powers and has limitations from a generating standpoint.

In general, we have a choice of two pressures, 2,200 volts or 6,000 volts, either of which can be used directly with motors for main drive. Experience has shown that if the distribution problems are not too serious, 2,200 volts should be chosen, as the machines for this pressure are much freer from insulation troubles than those for 6,600 volts.

There are two frequencies in use in the United States, 25-cycle and 60-cycle. In the early days of electrification, when it was thought that most generators in the mills would be driven by gas engines and that the motors would be directly connected to the rolls, the 25-cycle system seemed to be the logical one to adopt. At that time, the means of connecting the higher speed motors to mills were not very satisfactory. Since then gearing and other mechanical features have been very materially improved, so that the great majority of mills installed today use moderate speed motors geared down to the mill speed. The 60-cycle system has grown rapidly in favor during recent years and for main roll drive with proper connections is quite as satisfactory as the 25-cycle system. A further advantage is that the large power systems, which are gradually spreading over the country, are practically all 60-cycle and it is probable that in the future mills will find it profitable and desirable to purchase at least some of the power used. The 60-cycle system has a number of advantages as a greater range of motor speeds is obtainable and the machines are lighter and cheaper. The perfection of 60-cycle converting equipment, which was not available a few years ago, has materially changed the situation. The type of prime mover has an influence on the frequency adopted. Practically all gas engine driven units of the large size have been built for 25 cycles and there are some difficulties in the way of building 60-cycle units.

The choice of prime mover must be decided greatly by local conditions. In the early days the tendency was to use gas engines. The tendency today, however, is to use steam turbines and, as previously mentioned, improvements that are continually being made are reducing the difference in fuel economy between the two types. The first cost is an important item and one which seriously affects real economy.

To sum up, for the ordinary sized plant, the general practice today is to build a turbine station, generating current at 2,200 volts, 60 cycles, which is distributed direct to the mills.

Distribution.

In the older plants most of the distribution is overhead. This is somewhat cheaper in first cost than the other alternative of placing all our cables underground, but it is not nearly as satisfactory. The best system is to use insulated lead covered cables laid in ducts embedded in conduit which run to the different consuming or distributing points. A great many of these ducts can be grouped together to run in such a way as not to interfere with any of the other parts of the plant. This leaves our yards entirely free from overhead obstructions. The use of overhead lines is always attended with danger, not only to life but also from an operating standpoint, as frequently the lines are damaged or torn down when running locomotive cranes around the plants. The use of an underground system eliminates all danger from lightning disturbances. The high tension underground distribution system at Mark Plant has not had a single failure in five years of operation.

Substation Equipment.

We have the choice of either motor generator sets or rotary converters. The tendency is to use rotary converters, as they are lower in first cost and much more efficient. Motor generator sets give us the possibility of using substation equipment to improve power factor and in some cases they are justified. In a new electrification scheme, however, with proper design rotary converters are on the whole entirely satisfactory. It would seem that the greater loss in the motor generator set is an expensive way of improving power factor.

The development of automatic or semi-automatic control of substation equipment materially affects the question of substation layout and location. It is now quite feasible to control all our substations from the power house and the equipment is such that the only attention required is that which can be given by the motor inspector employed in the particular department where the apparatus is installed. This so reduces operating expense that we can afford to have more substations and save on our distributing copper. The freedom of layout gained thereby is a decided advantage.

Drives for Reversing Mills.

There is only one practical system to use. It requires a fly-wheel motor generator set for supplying power to a direct current reversing motor connected to the rolls, and it is not likely that this scheme will be changed by future developments. Details of the machines vary somewhat with different manufacturers and it is only necessary to point out that very substantial mechanical construction is necessary on account of the shocks to which the machines are subjected. Reducing the cost by light construction is not justified. The control equipment is very important and the manufacturers have used a variety of schemes. There is more than one way of solving the problem, but the final result should be that skill on the part of the operator is not necessary. It should be possible for the operator to simply throw his control handle from one position to another and for the equipment to automatically perform the desired result immediately in such a way that the machines are not distressed. If the machine can carry a certain load safely, the automatic controlling equipment should be so arranged that during each manipulation the machine is loaded to its safe operating capacity but no higher. The nearer this ideal can be approached, the better the control equipment. The control equipment should also be such that it can be set to limit the load on the power house to any predetermined figure and to always operate at this point. To have a really satisfactory equipment it is necessary to closely approach this ideal and the best equipment is one that does it with the simplest apparatus. Improvements in the future will probably be towards making the machines cheaper due to better design, but the main development will be towards simplifying and improving the control equipment to give an operation approaching the ideal as nearly as possible. Reversing mill equipments as made by the two principal manufacturers, have proved adequate and reliable. Provision should be made in the layout to insure that the machines are properly ventilated at all times and a failure of the air supply should shut down the equipment before it can be injured. The electrical design is in general best left to the manufacturer. For instance, whether single or double armature motors are used is immaterial unless it involves a machine of more than usual voltage. When the power required is greater than can be supplied by a single generator fly-wheel set, the tendency is to run two generators in series on one motor. If this involves using a total armature voltage of 1,000 to 1,500, it is preferable to use two motors and connect all the machines in series which, if they are arranged alternately, generator and motor will limit the voltage at any point to that of one generator only.

Calumet Steel Company Electrify Mills

Rotary Converter Adjustable Speed Sets as Applied to a Rail Re-Rolling Mill—Twelve Stands of Rolls Are Now Electrically Driven.

By L. H. HOOK and F. R. BURT

THIS paper deals with the electrification of the rolling mills of the Calumet Steel Company at Chicago Heights. Installation was completed, and the equipment put into operation approximately a year ago. The mills electrified are an 8 in. five-stand mill, and a 14 in. seven-stand mill.

The 8 in. mill was formerly driven by an 18 in. x 30 in., 120 to 150 rpm, simple non-condensing steam engine, through 17 1 in. ropes. The pulley ratio was 108 in. to 48 in., giving a mill speed of 270 to 337 rpm. A 14-ton, 11 ft. diameter fly-wheel was mounted on the engine shaft. This mill is of the simple merchant type, and is used for rolling small orders of varied product which cannot be produced economically on the 14 in. mill.

The 14 in. mill was designed for re-rolling rails into concrete reinforcing bar, tubes for fence posts and bedsteads, small structural shapes, etc. It consists of a seven-stand train, split into two drives. Five stands are driven from one end, and two stands with two additional stands of forming rolls from the other. The forming rolls are set in tandem after the bull head, and are driven by gears from the main shaft. They are used for shaping tubes, and require only a small amount of power.

A continuous furnace fired with powdered coal heats the rails, which are broken into convenient lengths before charging. An approach table with continuously running rollers leads from the furnace to the slitter, which is the fifth stand in on the five-stand drive. The first pass, which is taken between the middle and top roll, slits off the flange, which is then finished into tubing or small structural shapes on the two-stand drive. The second pass on the slitters, separates the web and the head, which are both finished on the five-stand drive. When finished, the bars are run out on separate cooling beds, and thence to the shears, straighteners, and to the Shipping Department.

This mill was formerly driven by two duplicate 26 in. x 48 in., 80 to 95 rpm, simple non-condensing steam engines, by means of 16 1½ in. ropes. The corresponding mill speeds were 160 to 190 rpm.

To supply the mill engines with steam, it was necessary to keep in service one 600 hp, and four 250 hp boilers, and the cost of attendance for the five boilers and three engines was necessarily large. At the time this mill was built, much lighter steel was used by the railroads than at present, and although the engines were large enough at that time, they were found wanting when 90 and 100 lb. rails began to appear as scrap, and also as the tonnage produced increased through more efficient methods. On the heavier schedules, the engines all slowed down considerably under load, and it was impossible to handle all the tonnage which the mills themselves would have been capable of turning out had they been supplied with sufficient power.

In electrifying the 8 in. mill, it was decided from past experience with the steam drive, that adjustable speed was not required, and a constant speed, 292 rpm motor of 500 hp capacity was installed, direct connected to the mill through a flexible coupling. The control for this motor is of the magnetic secondary type, with a hand operated double throw primary circuit breaker. This breaker is operated from a panel located near the mill, and the drive is started and stopped, or plugged when necessary by the roller or other authorized mill man.

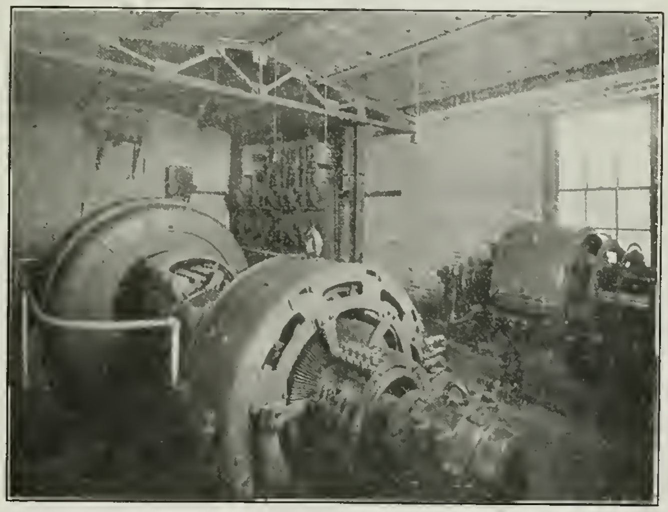

Fig. 1—14-in. mill motor room, showing 1,000-hp. adjustable speed set and control.

With the electric drive, the tonnage on this mill has been markedly increased, having been almost doubled on certain schedules. In 384 hours' operation, delays of 71 minutes have been charged to the electrical equipment. This is .3 of one per cent, based on the operating time. The first few weeks of operation are always the most trying for an electric drive. After the equipment has been in operation for some time, the various parts adjust themselves to each other, the bearings get worn in, the operators get acquainted with the machinery and learn how to handle it to the best advantage. It has been found on correctly applied electric drives that although the delays may be appreciable during this period, they become negligible later on.

The steam engines on the 14 in. mill were replaced

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*Paper presented before Chicago Section of the Association of Iron and Steel Electrical Engineers, May 15, 1922.

Mr. Hook is works manager, Calumet Steel Company. Mr. Burt is general engineer, Westinghouse Electric & Manufacturing Company.

by two duplicate 1,000 hp rotary converter adjustable speed sets of the constant horsepower type. It was thought advisable to have more speed adjustment than could be obtained from the steam drive, and accordingly these sets were designed for speeds of 450 to 590 rpm. Each is connected to the mill through a flexible coupling and a herringbone gear unit, specially designed with a short center distance between gear and pinion shafts. The reduction is 3.1—1 giving a mill speed of 145 to 190 rpm.

Each of these electric drives consists of a main wound rotor induction motor, a smaller direct current motor direct connected to it, and a rotary converter.

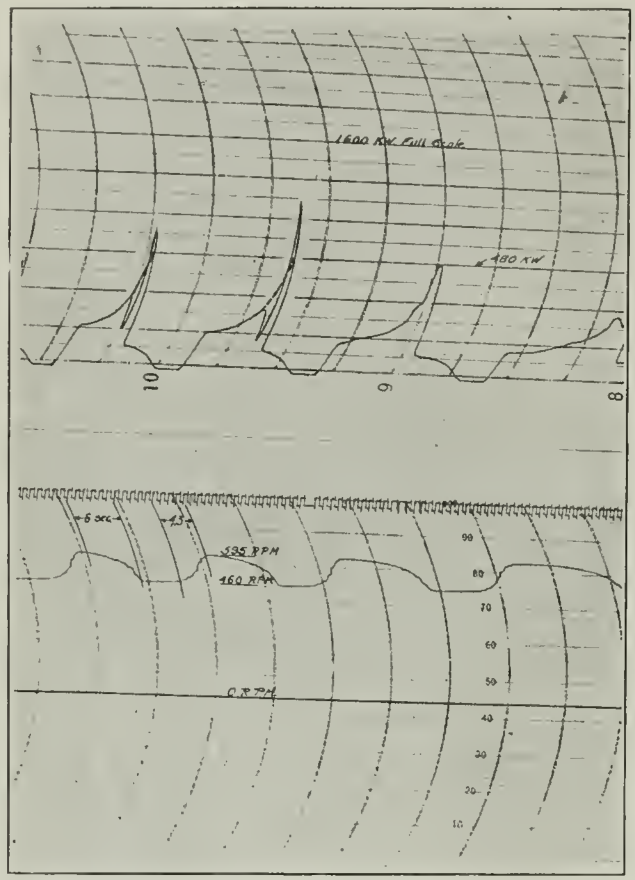

Fig. 2—Charts showing time required to change speed.

In any scheme for securing adjustable speed on induction motors, one of the auxiliary machines must be mounted on the same shaft if the advantages of constant horsepower throughout the speed range are to be obtained. An induction motor in itself is essentially a constant torque machine—that is, with a given current in the windings, the same torque will be exerted at all times, regardless of the speed. An induction motor exerts torque by virtue of the interaction of the current in the secondary and the flux set up by the primary. To circulate current in the secondary, there must be a voltage generated, and this voltage is produced by a difference in speed between the rotating field in the primary and the mechanical rotation of the conductors of the rotor. The voltage generated is directly proportional to this difference in speed or "slip." If it were possible to operate an induction motor at exactly synchronous speed, there would be no voltage in the secondary, consequently no current could flow, and the motor would produce no torque. If a load were thrown on this motor, it would not be able to carry it, and would immediately start to slow down. This slowing down would cause a difference in relative speed of flux and conductors, which would generate a voltage in the secondary. This voltage would circulate current, and the motor would immediately begin to exert torque. At some certain point during this slowing down process, a point is reached where the torque exerted by the motor is just enough to carry the load, and the motor operates at this speed until the load is again changed. The design of a good rolling mill motor, with short-circuited secondary, is such that a drop in speed of approximately 1½ or 2 per cent is sufficient to allow it to carry full load torque.

If a voltage is introduced into the secondary circuit which opposes the voltage generated by the slip, the motor must slow down to a point where the latter predominates by an amount sufficient to allow the motor to carry the load. For instance, if the locked secondary voltage of a motor is 1,000, and it drops 2 per cent in speed at full load, it indicates that 20 volts are required in the secondary to allow full load current to circulate. If now a counter voltage of 180 volts is impressed, the motor must generate 200 volts, or must drop 20 per cent in speed. The result is the same whether this counter-voltage is obtained from an external source, or whether it is due to resistance in the circuit. A resistance drop may be considered as a counter-voltage, since it absorbs a portion of the generated voltage. Any desired speed from full speed down to stand-still can be obtained by inserting the proper amount of resistance in the rotor circuit, but this speed with a given amount of resistance can be obtained only at one value of load, since at any other load, the rotor current, and therefore, the counter-voltage of IR drop are different. In other words, resistance in the secondary circuit simply exaggerates the natural speed characteristic of the motor, which varies from full load speed to synchronous speed, depending on the load. Since the induction motor delivers the same torque with a given rotor current, independent of the speed, it follows that the horsepower is directly proportional to the speed. The horsepower input from the line is constant, and the difference between the input and output, except for the internal losses in the motor, appears at the rotor slip rings. If the speed reduction is secured by means of secondary resistance, this energy is dissipated in the form of heat and is lost.

In order to obtain definite speeds which will not vary under changes of load, it is necessary to keep the counter-voltage constant by taking it from an external source, and this voltage must at all times be the same in frequency and phase position as that generated by the rotor, if the system is to be operative.

Hence, there are three prime requisites for a successful and economical alternating current, adjustable speed equipment:

(a) An easily controlled voltage must be impressed on the rotor.

(b) This voltage must be of the proper frequency and phase displacement.

(c) The energy in the secondary due to the slip must be conserved.

All ac adjustable speed sets are designed with these three objects in view, although they may differ in the type of auxiliary machines used, and in the use made of the slip energy. There are two main classes of sets. One delivers constant torque throughout the speed range, and the other delivers constant horsepower. An equipment of the former class feeds the slip energy back into the line, simply circulating this amount of power through the machines. Equipment of the constant horsepower type delivers the slip energy back to the shaft, increasing the torque in proportion to the speed reduction. The machines at the Calumet Steel plant are of the latter type.

On each set, the main 1,000 hp induction motor delivers $\frac{450}{590} \times 1{,}000$ or 763 horsepower at the low speed. The input at all speeds corresponds to 1,000 hp output. The difference between the input and output, in this case 237 hp, appears at the slip rings, and is transferred through the rotary converter, where it is converted to direct current and impressed on the direct current motor. The direct current motor changes it to mechanical energy, increasing the torque on the shaft and bringing the total output up to 1,000 hp. On this mill, small rails designated as 4 in. or less, are rolled at the high speed, while the slow speed is used for the largest rails. Rolling from 5 and 5¼ inch rails requires considerably more power than reducing the smaller sizes, hence the constant horsepower drive fits in admirably on this type of mill.

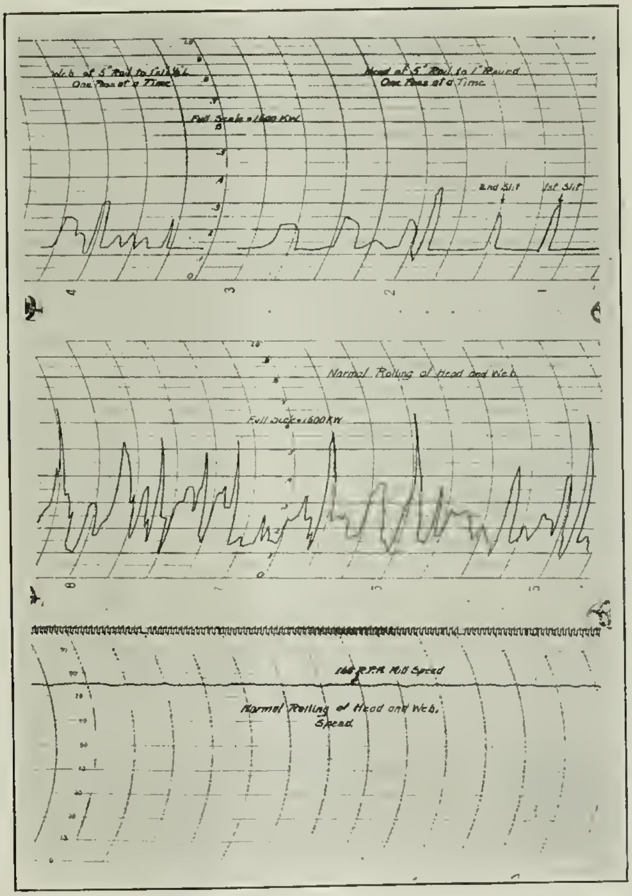

Fig. 3—Power required on five stand drive.

The starting and speed adjustment of these drives, are accomplished from the master switch, and a rheostat control switch. With the master switch in the "off" position the primary and secondary circuits of the main motor, the direct current circuit between rotary and direct current motor, and the field circuit leading to the rotary and direct current motor, are open. Moving the master switch to the first position closes the contactors which connect the secondary of the main motor to the starting resistance, provided the direct current motor field rheostat is in the "off" position, and the speed limit device on the rotary converter is set. The second point on the master switch closes the primary contactor, which, in turn, releases the first accelerating relay in the secondary circuit. The motor now comes up to speed, the secondary contactors which short-circuit the resistance being controlled by current limit relays, so that the current is maintained between predetermined limits during acceleration. The operation at this point is that of an induction motor with short-circuited collector rings, and if it is desired at the high speed, the master switch is left on the second point. The rotary is connected to neither of the other machines, and the field circuits are open. If it is desired to operate at reduced speed, the master is moved to the fourth point. The third point closes the field circuit to the direct current motor, whose rheostat is in the "off" position, and to the rotary converter whose rheostat is set for normal field current. The fourth point disconnects the secondary circuit of the main induction motor from the resistance, which is now short-circuited, and connects it to the slip rings of the rotary converter. The regulating circuit is now completed, but since there is no counter-voltage being generated, the only effect on the speed is that of the very small resistance introduced in the rotor circuit by the other machines. The main induction motor is rotating at nearly synchronous speed, and therefore, is generating practically no secondary voltage. The direct current motor, although running at full speed, has its field unexcited, and therefore, is delivering only a very small voltage, depending on its residual magnetism. The rotary converter, although its field is fully excited, has very little voltage across its terminals, and therefore, is at a stand-still, or very nearly so. However, if a field is now put on the direct current motor by moving the control switch which operates the motor-operated field rheostat, a voltage is generated which is impressed on the rotary converter, and through it on the secondary of the main motor. The machines are so connected that this voltage opposes that of the rotor, which must slow down and increase its slip voltage. When the latter becomes enough more than the impressed voltage to allow a current corresponding to the torque to flow, a point of equilibrium is reached, and the set operates continuously at this speed, with small variations under load, until the setting is again changed. Any speed within the range can be obtained by manipulating the rheostat control switch. If in case of emergency, it is desired to stop quickly, the master switch and control switch are brought to the "off" position and the master moved to "reverse." This impresses full voltage on the primary in the reverse direction and brings the motor quickly to rest.

A pulpit over one end of the mill contains the master switches and speed control switches for both sets, and also an operator's panel. On this panel there are mounted indicating wattmeters showing the input to both drives, and a voltmeter and ammeter in each direct current circuit. A system of signal lights indicates to the operator the position of the main incoming line circuit breaker for the plant, the hand operated circuit breaker for each set, and the electrically operated primary reversing contactors, all of which are located in the sub-station, and also of the principal contactors in the secondary circuit, which are located in the motor rooms. This control apparatus could have been mounted on the mill floor and operated by the roller, but it was considered that the time saved by having an operator on the job who had no other responsibilities would more than pay his wages.

The rapidity with which the speed of these sets can be changed, and their stability under such conditions are shown in Fig. 2. The upper chart is kilowatts input and the lower is revolutions per minute. The zigzag line on the upper margin of the lower chart represents time in seconds. In taking these readings, the field rheostat was turned by hand as rapidly as possible from one maximum position to the other. It will be observed that the speed was increased from minimum to maximum in 6 seconds with an input of 480 kilowatts, and that it was decreased from maximum to minimum in 4.3 seconds. The regenerative power during this operation is not indicated, as the pointer was against the stop on the meter. When these sets were put into operation, the three-point rheostats in the direct current motor fields were improperly connected, due to an error in the wiring diagram. This caused a section of resistance in one of the rheostats to burn out during the try-out while steel was in the mill. The operator, observing that the mill had come up to high speed, moved his speed control lever back and forth several times. Each time the rheostat arm moved across the open spot, full field was alternately put on and taken off the motor. Notwithstanding the fact that the set was loaded, it responded to these almost instantaneous changes of conditions with no signs of distress or instability.

Power for operating these drives is supplied by the local power company, the Public Service Company of Northern Illinois. It is brought into the substation on the property at 4,000 volts, which is the voltage used on the motors. In the substation are the main incoming line circuit breaker, the feeder breakers for the three mills, the "forward" and "reverse" primary contactors for the 14 in. mill drives, switching and transforming apparatus for the low voltage mill circuit, and a small exciter set, which supplies dc excitation for the sets.

The first chart on Fig. 3 shows the kilowatts input to the five-stand drive when rolling the head of a 5 in. rail to a 1 in. round, and the web to a 1 in. x 1 in. x ⅛ in. angle. One piece alone was run through the mill, and the power required for each pass recorded. The second chart was taken during normal rolling on the above sizes. It illustrates the building up of peaks by overlapping passes with several pieces in the mill. The maximum swing shown is 1,000 kw, whereas the maximum taken by a single pass is 560 kw. The third chart indicates revolutions per minute, and illustrates the very small drop in speed of this set under load.

Figure 4 shows the same readings taken on the two-stand drive when rolling the flange to 2 in. x 1½ in x ⅛ in. angles. The maximum peak under normal rolling is again 1,000 kw and the maximum individual pass 640 kw. Unfortunately, one of the heavier schedules was not being rolled at the time these graphic meters were connected in the circuit. During the hardest rolling, it is not unusual for the indicating wattmeter pointers to go off the scale at 1,600 kw, which is about 80 per cent overload.

In 2,700 hours operation on the two 14 in. mill drives, delays due to the electrical equipment have been 5 hours and 52 minutes, or .2 of one per cent. This delay time includes one or two occasions when the power was temporarily interrupted. Readings taken over a period of eight hours indicate that to roll 5 in. rails, the head being reduced to 1½ in. x 1½ in. x ⅛ in. "T" section, the web to 1 in. x 1 in. x ⅛ in. angle, and the flange to 1½ in. x 1½ in. x ⅛ in. angle, requires 73 gross kilowatt hours, per finished ton, and to roll the same rail into ¾ in. rounds, 1 in. x 1 in. x ⅛ in. angle and 1¼ in. x 1¼ in. x ⅛ in. angle, requires 61 kilowatt hours per ton. It is of interest to note that the total power consumption since electrification has been 88.5 kilowatt hours per finished ton of product. This includes all the electric power used in the plant.

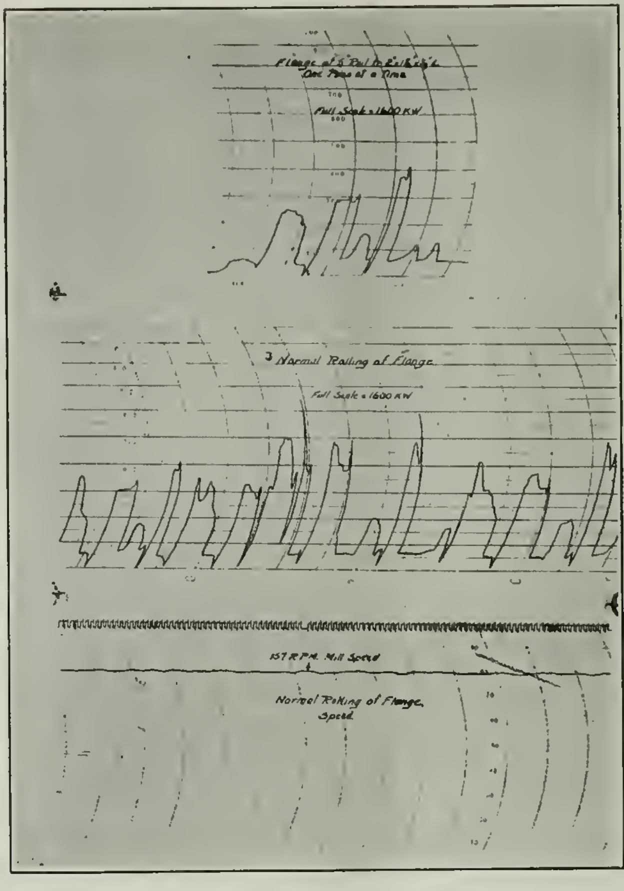

Fig. 4—Power required on two stand drive.

Maintenance and repairs on these drives during the year have amounted to $65.19, of which amount $60.00 was labor. This does not include the oil used in routine oiling of motors, but does include some used in switches.

The increase in tonnage with electric drive has been estimated at 10 per cent due to better maintenance of speed and greater ease of handling the drives. This is felt to be a very conservative figure. It has also been found that the roll breakage is less since electrifying. Since the heating furnace was changed over to powdered coal at about the same time, and more even heating is now being obtained, it is probable that this decrease in breakage is not entirely due to the drive, but the more even torques and higher finishing temperatures due to better speed maintenance undoubtedly have their effect.

The Effect of Oxidizing Gases at Low Pressure on Heated Iron

The Principal Agent in the Production of the Characteristic Facets of Oxide Is the Mixture of Gases Evolved by the Copper on Heating.

By H. C. H. CARPENTER and MISS C. F. ELAM*

THE experiments to be described in this paper originated in the following way: The authors were experimenting with the vacuum etching of copper which was heated in a silica tube, at temperatures in the neighborhood of 1,000 deg. C. The metal evolved a considerable volume of gas which, if allowed to remain in the tube, caused it to blister. If, however, the gas were pumped off as soon as it was evolved and the vacuum maintained, the copper remained bright and quite free from oxidation. Under these conditions the structure of the copper grains was rendered manifest by what may be termed a heat etch. It so happened that on one occasion Armco iron was placed in the tube with the copper, although not in contact with it. The tube was then evacuated and heated to about 1,000 deg. C. The gas evolved from the two metals was not pumped off, but allowed to accumulate in the tube. At the conclusion of the experiment, when the metals were withdrawn from the tube, it was found that each of them had altered considerably in appearance. On the one hand, the copper was found to have become coated with a layer of blue cuprous oxide, which in some places covered the metal completely, whereas in others it took the form of six-pointed stars deposited on the metal. On the other hand, the iron was distinctly lustrous, if rather dark, and appeared to be very deeply etched. Both specimens had been originally polished and sufficiently etched to show the outline of the crystal grains.

An experiment was then made by heating the iron itself in the absence of copper, and tests were made with Armco iron, electrolytic iron, and Swedish iron. In each case a considerable volume of gas was evolved, but no etching effects were produced and the iron appeared to be slightly oxidized. The characteristic etching effect observed in the previous experiment therefore was evidently due to something evolved from the copper.

A series of experiments was then instituted to study the progress and characteristic features of the etch produced on the iron when heated with copper. In all these cases the metals were separated from one another in the tube. The structure of the iron as revealed under the microscope was found to depend both on the period of heating and the temperature. After short periods, such, for instance, as half an hour, at 1,000 deg. C., the surface was found to be covered with small, somewhat irregular facets, whose orientation was constant on any one crystal but differed as a rule on passing from one crystal to another. Fig. 1, Plate I, shows the structure at 300 diameters of the surface of the copper. This is hardly etched at all, although evidences of twin crystals are manifest. In the center is a blue star of cuprous oxide of very characteristic appearance, and deposits of this constituent are also visible in other parts of the field shown. Fig. 2 shows at 300 diameters the appearance of the surface of the iron after the above treatment. Portions of three grains are visible. On each of them will be observed characteristic facets which are constant in direction on any given crystal, but vary from one crystal to another. There are also decided differences of level between the tops of the facets of the adjacent crystals. Steeply sloping surfaces connect one grain with another, and these slope to different extents. Between one crystal and another the etching is so deep as to produce what may be called a valley.

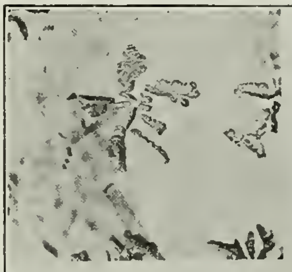
Fig. 1. Copper heated in vacuo in the presence of Armco iron. × 300.

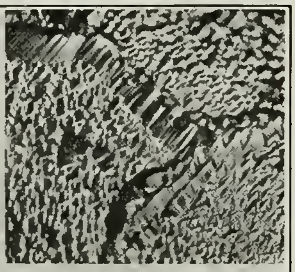
Fig. 2. Armco iron heated in vacuo in the presence of copper. × 300.

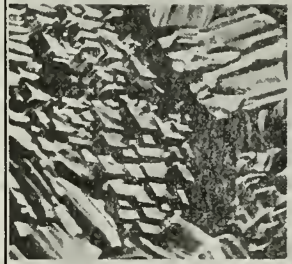
Fig. 3. Armco iron after more prolonged heating. × 600

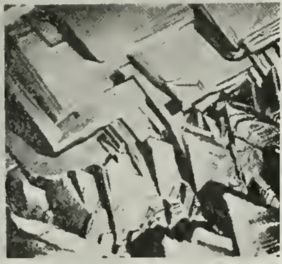
Fig. 4. Two adjacent grains of electrolytic iron after heating. × 300.

The differences of level on passing from one grain to another became still more marked as the heating was carried further. The individual facets then became larger and more regular, but the surface was rendered more uneven. Fig. 3 shows at 600 diameters the structure of Armco iron after the more prolonged etching. Regular brick-like facets are visible in the center of the field. The dark area bounding these on the right is a sloping boundary, while the facets beyond are out of focus owing to the difference of level. Fig. 4 represents at 300 diameters the structure of two adjacent grains of electrolytic iron which are much larger than those of Armco iron, and are both approximately in focus. The facets in the upper half of the field strongly suggest an orientation parallel to the cube face, whereas those in the lower half represent a section of a crystal cut obliquely. Not only were the crystals of electrolytic iron larger than those of the Armco iron, but also the facets themselves.

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*Paper presented before British Iron and Steel Institute Annual Meeting, May, 1922.

On heating for a longer period, say for two hours, the surface became still more uneven and was found to be covered with perfectly regular squares, rectangles, and triangles, together with other figures of less regular shape. Figs. 5 and 6 at 600 diameters are typical examples of the structures thus obtained. In the former the rectangle etch figures predominate and in the latter the triangle. In these cases, owing to the very deep etch, only certain parts of the field can be obtained in focus at any given time. It was observed that the size and general form of the figures varied somewhat in different experiments owing, doubtless, to slight differences in pressure, and to variations in the composition of the gases evolved from both metals. Occasionally very minute etched figures were obtained, such as are illustrated on Plate II, Fig. 7, at a magnification of 600 diameters, which represents part of one crystal in which the etched figures appear as minute squares and rectangles. Substantially the whole of this field is in focus. The three or four irregularly shaped figures observed are due to slight porosities in the iron.

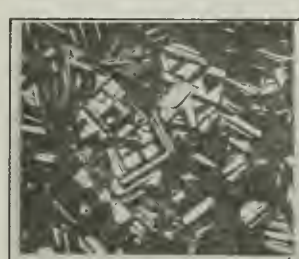
Fig. 5. × 600.

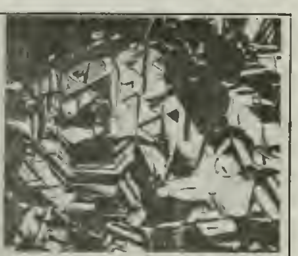
Fig. 6. × 600.

Armco iron after heating in vacuo for two hours showing rectangular and triangular figures.

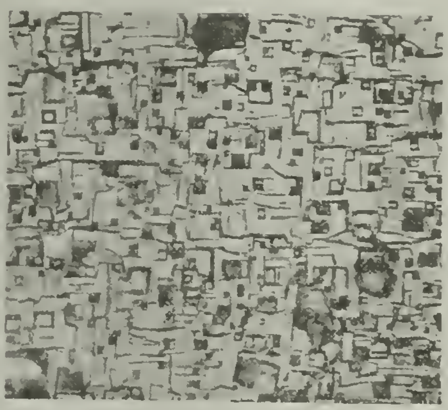
Fig. 7. Crystal of electrolytic iron showing minute square and rectangular figures. × 600.

It remains now to consider what the etched figures really represent. The authors' first idea was that the structures observed were those of the etched iron, more particularly as the form of the figures agreed very well with what is known as to the crystal forms of gamma and alpha iron. It very soon became evident, however, that the hypothesis was not correct in this form. It was found that, under certain conditions, small black shining crystals were formed on the surface of the iron, in addition to the etched figures described above. It was thought that these might be an oxide, and in removing some with a penknife in order to test it with a magnet, it was noticed that the "etch" layer could also be removed, revealing unaltered iron underneath. It appeared therefore that the characteristic etch figures were due to an oxidation of the iron during heating, and that accordingly they must be ascribed to an oxide and not to the metal. General support to this view was given by the fact that the copper itself was, as has been mentioned, also oxidized, the surface in certain places being almost completely covered with the characteristic blue cuprous oxide.

Further experiments were then carried out to determine what relation the structure of the oxide bore to that of the iron. It was noticed that if the specimen were heated to 1,000 deg. C. several times, there was no change in the shape or size of the characteristic etch figures, although it is obvious that on every occasion a change in the crystal form of the iron itself must have taken place on passing through the Ac3 inversion and back again through Ar3. In other words, it is clear that the alpha to gamma and gamma to alpha change had no influence on the facets once they had been produced. Moreover, on marking a particular area before heating it could be shown that its structure corresponded with that of the original alpha iron crystal. The boundaries were the same in both cases. On repolishing and etching after heating it bore, however, no relation to the metal underneath, which had recrystallized in passing through Ac3 and Ar3. Furthermore, upon heating the specimen of the iron below 900 deg. C. it developed the same characteristic etch facets as at 1,000 deg. C., although the time required was considerably longer (a minimum of two hours). It is clear therefore that the formation of the oxide begins below 900 deg. C. and that it takes its shape from the structure of alpha iron, and having once begun it continues to grow, regardless of the phase changes which take place in the iron underneath on passing from alpha to gamma and back again. The authors do not regard the process merely as an oxidation of the iron crystals, by means of which the structure of the iron is made manifest, so much as a growth of crystals of an oxide, the orientation of which is determined by the iron on which they are first formed. In certain instances the valleys produced at the boundaries are caused by the growth of oxide crystals away from the true boundary in two directions, the slopes of the valley being made up of the "sides" of the crystals. It will be noticed that these are striated in a regular manner corresponding with the orientation of the facets observed on the surface.

The fact that one substance will assume the same orientation as that of another on which it is crystallizing, provided they are isomorphous, is well known. This was established, for example, by Mr. C. V. Baker[1] in his experiments on "the formation of regular growths of crystals of one substance upon those of another." Parallel growths of sodium nitrate crystals on calcite surfaces are shown on Plate XX, Figs. 63, 64 and 65, of Sir George Beilby's book entitled "Aggregation and Flow of Solids." It seems probable, therefore, that in the present case the oxide first formed is magnetite Fe_3O_4, which has a cubic symmetry like alpha iron. The surface crystals, however, which were removed with a penknife, were not attracted by a magnet, indicating that they had been further oxidized, probably to Fe_2O_3, without change of form. It is well known that hematite crystallizes in the hexagonal system, but this oxide has been obtained in a form pseudomorphous with magnetite by heating the latter in a blow-pipe flame for several hours. The crystals oxidized without change of form.[2] A type of structure somewhat similar to that described above was obtained by Osmond and Cartaud.[3] They heated to redness a crystal of iron (which had one of the cube faces polished) in a nickel crucible packed with calcined magnesia and covered with cast iron shavings. To use their own words in describing the results of this experiment: "The polished face oxidized naturally and displayed square figures strongly resembling corrosion figures. * * It seems that the oxidation has been regulated by the structure of the metal."

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[1] "Journal of the Chemical Society," 1906, vol. lxxxix, p. 1120.

As has been already stated, the characteristic structures of oxide described in the present paper are only produced under the combined influence of the gases evolved from both copper and iron. The mere oxidation of the iron which always takes place to some extent when it is heated by itself in an evacuated silica tube, does not produce these structures at all. What has to be explained, if possible, is the oxidation of the iron in a particular way under the combined influence of the gases simultaneously evolved both from iron and copper. The effects are only produced by copper containing the gases normally present in the metal. If the copper be previously heated in vacuo several times until no gases are evolved and be then heated with iron in an evacuated tube, it remains quite bright, while the iron oxidizes slightly without the production of the characteristic facets of oxide. Both the composition and volume of the gases contained in copper vary within fairly wide limits. Several samples of the metal, however, produced similar effects on the iron. The action therefore clearly takes place with gases whose composition varies to some extent. The gases collected when one specimen of the copper used in the authors' experiments was melted in vacuo, gave the following results on analysis:

Hydrogen sulphide	61.2
Carbon dioxide	34.9
Oxygen	1.1
Residual gas (nitrogen)	2.8

It is to be noted that this mixture contains only just over 1 per cent of free oxygen, but that there is a considerable amount of oxygen present combined with carbon and sulphur. Less information exists with regard to the gases present in iron. The majority of gas analyses have been carried out on steels, and in these cases the gases appear to consist of mixtures of the oxides of carbon together with hydrogen and nitrogen. It is impossible to predict what would be the equilibrium in a system composed of the metals, copper and iron, at temperatures of from 900 deg. to 1,000 deg. C., which was evolving a mixture of the above types. Broadly speaking, however, it appears that under these conditions the atmosphere produced is decidedly oxidizing both as regards the copper and the iron. In their experiments the authors have noticed the deposition of free sulphur in the cooler parts of the quartz tube. This points to the decomposition of the sulphur dioxide always present in the copper, and the result would be the production of free oxygen. Another source of this gas is possibly the decomposition of some cuprous oxide. The fact that the production of the characteristic facets of oxide requires a period of considerable duration for its completion is due, no doubt, to the gradual liberation of the gases over this period. Those contained in and evolved from the copper must be held to be the chief cause of the characteristic structures of iron oxide produced, but the influence of their possible interaction with the gases evolved on heating the iron itself must not be lost sight of.

Summary.

Samples of Armco, electrolytic, and Swedish iron were heated from below 900 deg. to above 1,000 deg. C. in an evacuated quartz tube and oxidized slightly without producing any characteristic crystallographic features on the surface of the metal. If, however, a specimen of copper be introduced as well containing the gases which are ordinarily present in the metal, a reaction sets in resulting in the gradual production and development of characteristic facets on the surface of the iron. These are due to the production of what is probably the oxide Fe_3O_4 which subsequently passes to Fe_2O_3 without change of form. The oxide of iron originally produced is isomorphous with alpha iron, and the orientation of the oxide produced on any given crystal of iron is determined by the orientation of the alpha iron itself. It is, in other words, "a parallel growth" of the magnetic iron oxide. Once produced the form of the oxide is uninfluenced by heating the specimen to a temperature at which gamma iron is formed. A somewhat similar phenomenon was observed sixteen years ago by Osmond and Cartaud. The principal agent in the production of the characteristic facets of oxide is the mixture of gases evolved by the copper on heating.

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[2] Friedel, "Bull. Soc. Franc. Min.," 1894, vol. xvii, p. 450.

[3] "Journal of the Iron and Steel Institute," 1906, No. III, p. 481.

STUDY OF FLUORSPAR INDUSTRY

R. B. Ladoo, mineral technologist of the Bureau of Mines, spent the entire month of April in the examination of the fluorspar deposits of the western states. On this trip fluorspar mines and mills were examined in New Mexico, Nevada and Colorado. Information obtainable on fluorspar deposits in Arizona, California and Utah indicated that deposits were not sufficiently important to warrant examination. None of the mines or mills visited was in operation, and it was evident that many of the deposits opened, particularly those of New Mexico, were war developments which can not be considered of great importance under normal conditions. The information obtained on this trip will be used as the basis of a report on the mining of fluorspar in the western states.

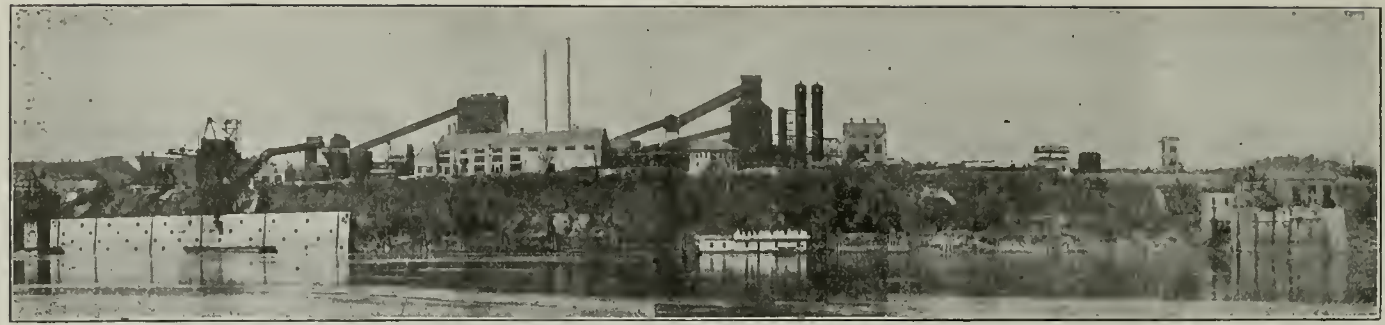

Fig. 1—General view of by-product coke plant.

By-Product Coke Plant at Midland

The Pittsburgh Crucible Steel Company Has Completed a Modern Plant Consisting of 100 Koppers Ovens at Midland, Pa.

THE By-Product Coke Plant of the Pittsburgh Crucible Steel Co., consisting of 100 Koppers ovens is situated at Midland, Pa., about 34 miles below Pittsburgh on the Ohio River on the site of an old Bee Hive plant. The original plans called for a plant built with government assistance as a war time measure to supply toluol and ammonium sulphate; but after the Armistice these arrangements were concluded, and the plant completed by the Pittsburgh Crucible Steel Co., a subsidiary of the Crucible Steel Co. of America. The location makes possible the use of the cheap water transportation giving the plant a decided advantage over those dependent on rail haulage.

As a source of raw material for the By-Product Coke Plant, the Crucible Steel Company operates a coal mine at Crucible, Pa., 69 miles above Pittsburgh on the Monongahela River at Glassmere, Pa., on the Monongahela. The mine at Crucible is in the Pittsburgh seam, admirably located and is capable of large development. As the acreage here is large and the coal readily mined and delivered into barges on the river, this is logically the source of supply of most of the coal for the By-Product plant. The mine at Glassmere is in the double Freeport seam and has a smaller acreage. At present it is not possible to load barges from the mine but when the river work under way is completed it will be possible to deliver coal from this mine into barges for shipment to the By-Product Coke Plant.

Coal is taken from the barges by a Mead-Morrison hoist having a six-ton bucket with a capacity of 600 tons per hour when working in free coal. The lift at normal pool stage is 75 feet and the speed of hoisting is sufficient to make two trips per minute.

The hoist is provided with a two hundred ton bin from which the coal is fed by a shaking feeder on to a 42 in. conveyor belt. This conveyor is 605 feet long and the idlers are equipped with roller bearings to decrease the strain on the belt. The storage bin here serves to balance the capacity of the belt, which is 300-326 tons per hour, and the hoist; and to keep the belt supplied with coal while charging barges. This first conveyor handles not only the coal for the coke plant but also the steam coal and coal for the gas producers. The coal is delivered into the junction tower at the rate of 300-325 tons per hour where it is divided—250 tons per hour going on a 36-inch belt to the breaker and mixer building and the remainder on a 42-inch belt to the loading station, where if desired it may be crushed by a 54 x 54 roll crusher and screened into lump and slack for the steel mill. The capacity of this crusher is sufficient to take the entire amount delivered by the river conveyor.

As the river is not navigable part of the year sufficient storage must be provided to allow the plant to operate during this period. This is taken care of by extending the ore yard and car dumper. Coal loaded into cars at the loading station is dumped at any desired point in the ore trough by the movable Wellman-Seaver-Morgan Car Dumper, which also handles the ore. From here it is stocked by the ore bridge. The maximum capacity of the storage yard is approximately 200,000 tons of coal giving 90 days operation for the Coke Plant and Steel Mill.

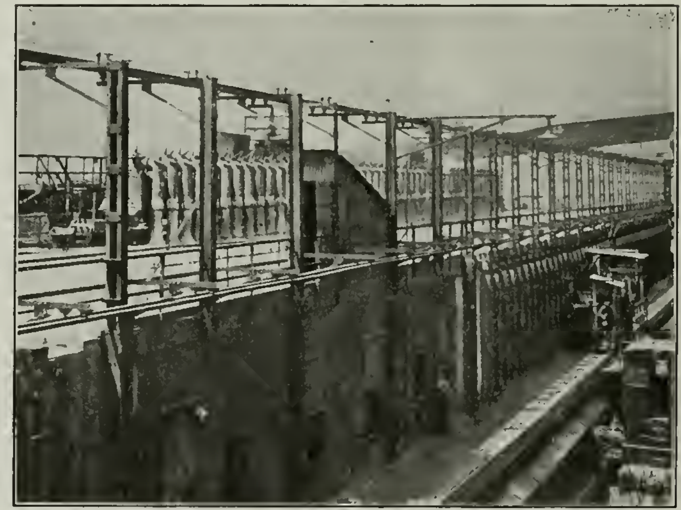

Fig. 2—View showing top and discharge side of ovens. Quenching car locomotive at extreme right.

In reclaiming coal it is loaded on cars by the ore bridge and transferred to the track hopper. This receives coal in two sets of hoppers and delivers through shaking feeders on to a 36 in. belt which in turn delivers it into the same junction house which is the terminal of the river conveyors. If desired it is possible to take run of mine coal from stock in cars, crush and screen it into lump and slack and return it to cars.

The coal handling is thus flexible; and large storage capacity and handling facilities obtained with small additional expense by utilizing the surplus capacity of the Blast Furnace Equipment.

The coal from the junction tower is delivered to the top of the breaker and mixer building through the Bradford Breaker to four 200-ton mixer bins. From these it is delivered to the mixer conveyors and the hammer mill and then to the 1,800 ton storage bin on top of the ovens. This bin is divided by a central partition so that it is possible to charge two kinds of coal in the ovens. From the barges in the river to the point of delivery at the top of the bin on the ovens the difference in elevation is 207 feet.

The ovens are Koppers 500 cubic foot ovens, 15¾ in. wide at the pusher side and 18¼ in. at the coke side. The jamb brick are unusually thick giving very effective insulation of the first flue and are also so arranged that the luting clay is not next to the buckstays. In case of gas leaks through the luting clay the flames will not have a chance to come in contact with the buckstays and cause them to bend. Once this process has started it is very difficult to stop and a leaky battery is the usual result.

The general arrangement of the ovens and machinery represent Koppers standard practice. The details of the present pusher track however, presents a difference from the usual practice in that there is no provision for taking the thrust of the ram on rear set of wheels. The wheels next to the oven are double flanged while those on the outside are single flanged with the flange on the outside, allowing this wheel to slip but preventing it from taking any thrust. The electric circuit for the pusher machine has a separate circuit breaker in the sub-station so that any attempt to push a sticker by holding in the circuit breaker in the pusher cab will cause the breaker in the sub-station to act. There is also a graphic meter in this circuit so that it is possible to observe whether there are any ovens which cause trouble in pushing. This arrangement has proven quite successful although viewed with suspicion at first. With the twelve foot embankment close to the rear wheel of the pusher this is apparently a very satisfactory solution.

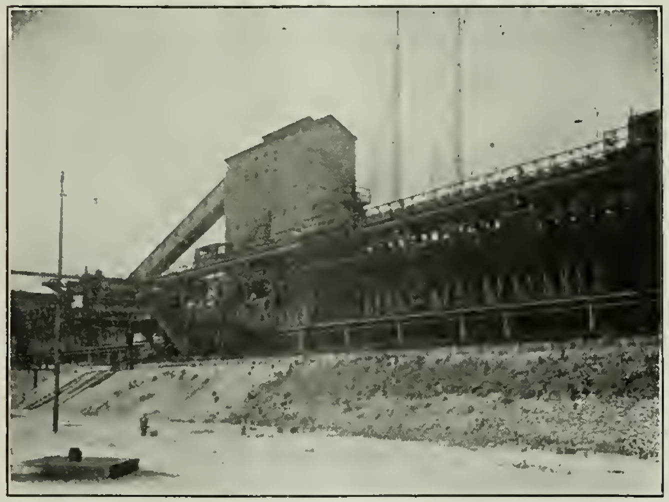

Fig. 3—Pusher side of ovens, showing pusher, central coal storage bin over ovens and gas collecting mains.

The coke from the ovens is pushed into a quenching car propelled by an electric locomotive, quenched and dumped from the quenching car onto the coke wharf. From here a 36 in. belt conveyor takes it to a rotary screen having 1¼ in. round holes. The furnace coke can either be loaded on cars on the coal handling level or sent to the storage bin above the transfer car which runs over the trestle to the blast furnace bins. The coke which goes through the 1¼ in. round holes drops onto an 18 in. belt which conveys it to a shaking screen having ⅞ in. round holes. The material falling through the holes is sent to the boiler house for fuel while the larger coke is sold as domestic fuel. Below this screen are two tile lined bins holding about a carload each. The tile lining seems to be standing the wear exceptionally well.

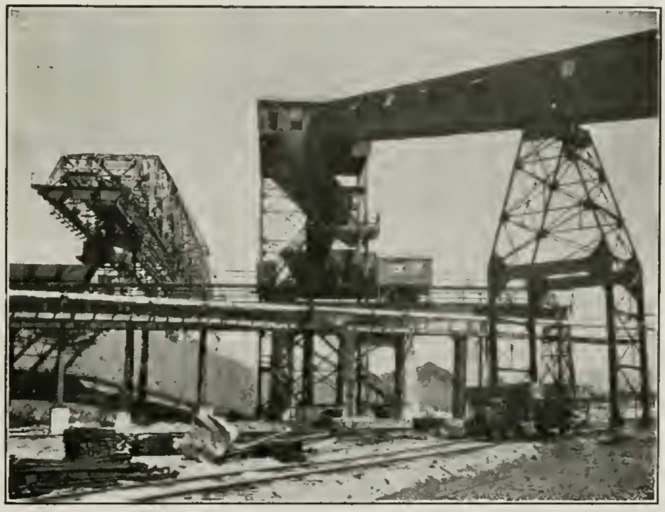

Fig. 4—Coke loading station, showing electric transfer car for conveying coke to blast furnace. Coal storage bridge at rear.

The By-Product Building houses all the by-product apparatus, the ammonia still not being in a separate building as in some of the recent plants. The exhausters are of the positive type—175 cubic feet per revolution. These are sufficient to take all the gas from both batteries, and the tar extractor, reheater and saturator are designed so that either may be operated with either exhauster but one is sufficient to take all the gas. The saturators are of the elliptical type with two ejectors and drain tables and three sulphate driers. It is thus possible to remove and repair an ejector while the saturator is in operation and to have one sulphate drier down for repairs without changing saturators as two driers will handle all the sulphate a saturator will produce.

As originally installed the wall between the booster room and main by-product apparatus room was only carried part way up to allow the hand crane to serve the booster room as well as the apparatus room, but it was believed that this advantage was outweighed by the danger of gas leaking from the apparatus room being ignited by the motor driven boosters, so the wall was made solid. The boosters are positive machines driven by 275 horsepower slip ring alternating current motors through a Lenix Drive. The speed of the motors is controlled by a master switch operated directly by the movement of the gas holder. The control will cause the booster to put all the surplus gas into the mill gas line. In case the Open Hearth Department where all the gas is used, does not require the full amount, the excess will be released into the bleeder line through a multi-port relief valve set at 5 pounds pressure. If desired however, a manual control in the booster room may be used.

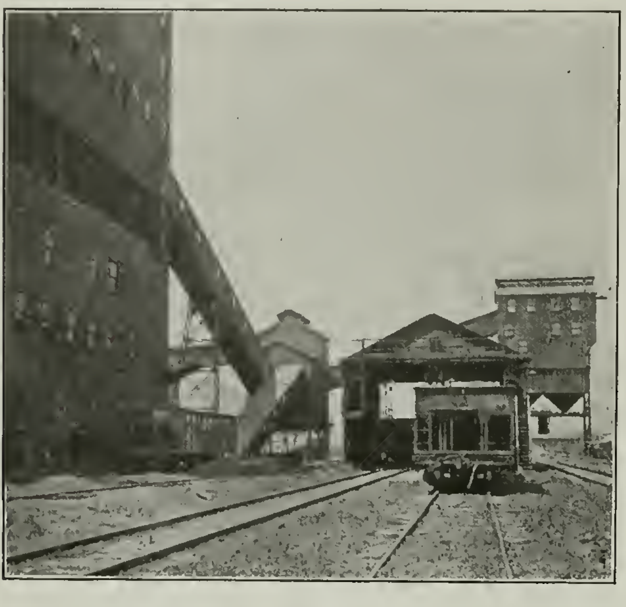

Fig. 5—Left to right: Coal crushing and mixing building; junction tower; coal to coke plant or steel work; rail coal to coke plant; right-rear, river coal to railroad cars for plant use.

The tar and liquor pumps are motor driven, direct connected centrifugal pumps with steam driven duplex pumps as spares. Centrifugal lime pumps, motor driven are also used for providing lime feed to the ammonia still. Tar is delivered through a four inch line direct to the open hearth storage tanks without the necessity of loading it into tank cars. Coking 1,800 tons of coal a day and taking the open hearth requirements as 6,000,000 Btu per ton of steel there will be available from the coke plant sufficient gas and tar to produce 1,390 tons of steel per day in the open hearth.

As the present coal handling tracks of the plant runs over a fill on the site of beehive ovens which were in a fair state of repair at the time by the by-product coke plant was built, the difference in the open hearth department fuel bill, had the old bee hive ovens been used to produce the coke for the blast furnaces, and natural gas been purchased as in previous years, can be readily computed.

The benzol department is fortunate in having the final gas cooler and benzol scrubbers located close enough to the building so that one man can operate the entire set of apparatus for recovering the light oil. This is a great advantage as the responsibility is not divided between the by-product and benzol departments as in many plants. The main benzol building houses the light oil stills and finishing stills, the agitator being in a separate building at the other end of the benzol enclosure.

The finishing stills are only designed to turn out 50 per cent of the finished product as pure benzol or toluol, it being expected that the bulk of the demand would be for motor benzol or other products not requiring as close fractioning as pure benzol or toluol. Duplex steam pumps located in the main building handle the different products. The absorbent oil is pumped by rotary pumps each driven by a separate engine.

The storage tanks are not located in a building as in many of the recent plants but are outdoors. Those intended for products liable to freeze are insulated and have heating coils.

To prevent loss of oil all the drains do not go direct to the sewer but to an intercepting sump where any oil may be recovered and pumped back into the system. Used absorbent oil and residual from the finishing still are pumped to the tar tanks.

All the electric wiring in the plant is carried in underground conduits. The main lines from the power house to the sub-station, both direct and alternating current are in duplicate. Should an accident disable both of these lines power can be obtained by a tie from the river pumping station. The main high tension switches have sufficient rupturing capacity to take care of the full generating capacity of the power house. Since the actual load on the direct current machinery is small it was deemed inexpedient to install rotary converters at the sub-station but to use the converters already in operation in the power house. With the complete duplication of units and switching apparatus in the power house the interruptions of coke plant operations due to the power being off have been very few.

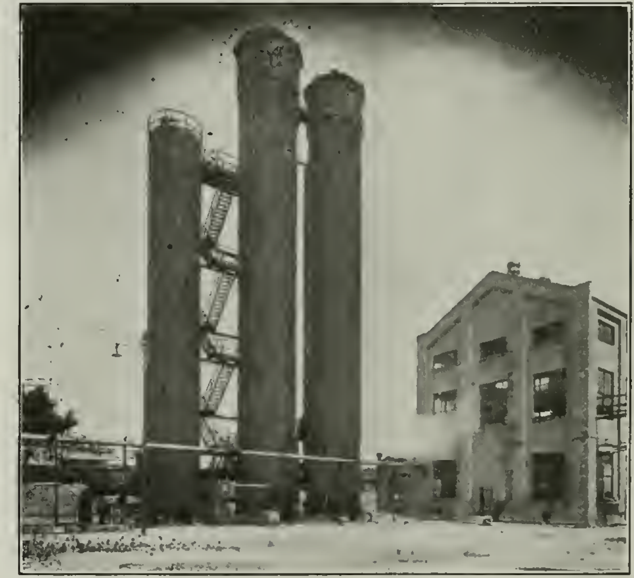

Fig. 6—Benzol scrubber, final cooler and benzol plant. Two benzol washers and one final cooler shown were manufactured by Treadwell Construction Company.

Steam is supplied from the blast furnace boiler house and the coke plant is also dependent on the steel mill for its supply of water.

Wire Manufacturing in England and France

General Comparison of the Wire Drawing Practice of England and France With That of the United States—Reasons for Differences in Method of Manufacture Given.

By KENNETH B. LEWIS

THE wire manufacturer of England or of France has one strongly marked trait in common with his brother in America. He does not invite the public to share his troubles and achievements, nor to discuss his problems. There is little or none of the interchange of experience through the technical press or the engineering societies that marks many other branches of the steel industry. The more one knows about wire, the less he talks, and though this statement may seem to classify the present writer rather unkindly, it is none the less true. Our wire manufacturers travel abroad, and the foreigners visit us, particularly the British, and while the differences in practice are noticed and criticized, no one is convinced. Few changes of practice are attempted as a result of these visits, and those few are frequently disastrous.

In recent visits to Europe, I have had an unusually good opportunity to compare in a very general way the wire drawing practice of England and France with that of the United States, and to go far enough into the difference to assign to each a logical reason. I look upon the foreigner no longer as an amiable eccentric, but as a man who has cleverly adapted his wire drawing practice to conditions outside of the industry, and beyond his control. In England particularly, conditions of land tenure, character of labor, and the influence of trade unionism, combine in various ways to affect profoundly the practice in the wire mill. These influences affect the problem in so many degrees and from so many angles that one scarcely knows where to begin a discussion of them.

It is commonly reported that the British make better wire than we. They do. The statement should, however, be amplified. They make better wire than we *do make,* but not better than we *can make.* The wire industry falls naturally into three divisions: the rolling of wire rods, the drawing of wire and the working up of the wire into finished articles. With us these three divisions, or at least two of them, are very commonly found under a single management, and a single roof. It is frequently found that the finished product of one division, which is the raw material of the next, can be considerably cheapened if the next division can take a product less accurately sized. The next division finds it possible, at a slight sacrifice in efficiency, to absorb the cheaper product, and to pass on a satisfactory raw material to the next in line. The gain greatly outweighs the loss, and as it all goes into the same pocket, a net gain is registered for the combined industries, while one or more of the divisions is forced for the common good to lower its standard.

In England the wire maker knows little and cares less about the problems of the rod roller. He wants round rods true to gauge and gets them. The nail maker, who draws no wire, wants his wire round and true to gauge, not because the carpenter cannot drive a scratched nail, but because the output and upkeep of the nail machines are better with first-class wire. Furthemore, the wire drawer and the nail maker are 100 per cent unonized. They are on a piecework basis, and if they do not like the raw material they get they will walk out. They consider they have no interest in common with the boss. Savings mean nothing to them. Earnings are everything.

The various divisions of the wire industry are very reluctant to merge to a completely integrated unit. The British companies are old and firmly established. They are family affairs, and the Britisher is not easily transplanted. He wants his family business with its small but steady profit, and his son wants it after him. He does not shift readily from place to place or from business to business. Moreover, a consolidation which involves expansion is a big undertaking in England on account of the difficulty of buying land. The Englishman regards his land as he does his business, not as a thing to speculate with, but to keep and get dividends from. There is no land held for speculative purposes. It is all producing. You may lease it, but, generally speaking, you cannot buy it, and there is not much fun sinking money in a big undertaking on leased land. The established units of the business are chiefly in congested districts, since they were laid down before the days of easy transportation. If they are to be brought together it must be in a new place. Will the workmen follow the plant? That's an open question. The British working man does not care for change any more than the manufacturer. One of his ambitions is to die in the house where he was born. The British manufacturer cannot count on attracting to a new location a sufficient number of floaters. There are no immigrants in England—no great floating body of unattached young men with nothing but muscle, ready to be shaped into skilled or semi-skilled laborers. The manufacturer can look only to the ranks of union labor. He cannot make wire drawers or nail makers. The union makes them, the boss takes them.

The labor union is the outstanding factor in the industry from every angle. British wire is generally drawn very accurately to gauge, whatever its grade. In conditions under which the American wire drawer handles four, five and even six blocks, the British wire drawer is permitted by the union to run only two. He has an abundance of time on his hands. His pay, while low in dollars per day, is high in dollars per unit of production. The boss can get square with him only by insisting on a high degree of accuracy in the finished product. The boss studies out other ways to keep the wire drawer busy. A Yankee would say that he was "saving at the

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Mr. Lewis is manager of the wire machinery department, Morgan Construction Company, Worcester, Mass.

spigot and wasting at the bunghole," but the critic must remember that the bunghole is in charge of the union, and is kept wide open, and that every drop saved at the spigot is net gain to the boss. The wire drawer is required to fix his own dies. This saves money, but it helps to rivet the shackles of trade unionism onto the boss. It helps to make and keep wire drawing a highly skilled trade. The wire drawer is required to point his wire frequently with no other tools than a hammer and anvil. The arrangements for drawing the point through the die are of the crudest description and great wasters of time, but the wire drawer has time to waste. In some mills the wire drawer must walk into the baker, pick up a bundle of rod from the floor and carry it in his arms to the bench. When I was tempted to marvel at the shortsightedness of the superintendent in permitting such inefficient practice I recalled that the man's time and labor were already paid for and that this service cost the mill absolutely nothing. The same considerations result in the use of small rod bundles. All the expenses connected with the production and handling of large bundles would fall on the proprietor. All the profits would go to the union wire drawer.

The British wire drawer is a highly skilled artisan. He serves a long apprenticeship, and works his whole life at the bench. He knows instinctively how to vary his drafting and the shape of the die hole to suit the variations in the stock, and he does certainly make beautiful wire. So did the American wire drawer in the good old days before the changing character of our labor supply made it necessary to take the brains out of the operator and put them into the machinery.

The British cleaning house is not quite the choking, steam-filled purgatory to which we are accustomed. I do not recommend it precisely as a health resort, but you can at least walk about without necessarily ruining a hat and coat, and on leaving you can blow your nose without burning holes in your handkerchief. The first thing I noticed was that all the tubs were of stone, reported to be everlasting. We have all heard of these stone acid vats from returning travelers. Some of us have tried them here in America, but they invariably cracked as soon as the solution got up to pickling heat. In England the solution gets no more than lukewarm, and the reason the wire cleans is that the acid is muriatic. This is not reckless extravagance on the part of the British wire manufacturer. Muiratic is his cheapest acid. In America we not only have large sulphuric deposits, but we recover thousands of tons of sulphuric acid as a by-product in the smelting of sulphide ores of the non-ferrous metals. In England sulphuric is the high priced acid, and muriatic is the cheap by-product. At this gentle heat generated by the chemical action of acid on steel, the stone tubs last forever, and on account of the strength of the acid, pickling is not prohibitively slow. The acid cannot be heated. Sulphuric acid is a liquid. Muriatic acid is a gas, which for commercial use is dissolved in water. At such temperatures as we induce in our vats by the use of steam, the muriatic acid would be driven out of solution and lost.

British practice seems to favor a long baking at comparatively low temperature. Whether this fully explains it, I do not know, but certainly their wire is more carefully "gotten up," as they express it, and if required will stand more drafting before the coating is lost.

Soap is the favorite lubricant in the die box, or rather the plate stand, as cast iron dies are unknown; not powdered soap, however, but soap in cakes or small chips. The cakes are commonly clipped onto the wire in pairs with a spring clip, and the rod is thoroughly soaped in the first draft. On succeeding drafts it is soaped again, either with cakes or with the broken chips and powder recovered from the first stand.

The British annealing practice does not seem to differ materially from ours.

In the matter of drawing benches, the differences are not particularly noticeable. The English bench is apt to be very low, perhaps 24 inches, but the block stands high above it so that the draft line is about the usual 30 inches from the floor level. The bench top is low enough to carry anvils, on which plates are battered.

Continuous machines for the dry drawing of coarse wire are much in evidence in England. They are of a variety of types, most of them familiar to Americans. Indeed, most of them have been tried here and condemned. Their work is no better in England than in America, but it seems better by contrast. The unions consent to classify a continuous machine as one block, and a man is therefore permitted to operate two machines. However small his output, it is bound to beat the performance of two single-holers. Three general types of machine are in service: the common slip machine, the machine with bronze segments which slip in a groove in the block face, and various arrangements of the differential gear principle. On account of their relatively large output, the British wire man nurses them along with greater care than we can afford to give them. The following figures indicate roughly the position of these machines in comparison with single holing in Great Britain, and in the United States:

Operation	British Output (10 hrs.) 1 Man 2 Blocks	 1 Man 2 Continuous Machines	American (10 hrs.) Output	 No. Blocks
2-hole No. 10	5040	....	9000	2
3-hole No. 11	4172	4480	8000	3
3-hole No. 12	3360	4028	7000	4
4-hole No. 13	2460	3920	6000	4
4-hole No. 14	2094	....	4700	5
5-hole No. 15	1346	....	3800	5

France.

I found the wire mills of France interesting, chiefly from the viewpoint of the antiquarian. This rather unkind statement might have been modified had I found time to visit some of the larger mills outside the devastated region, whose practice, I am told, more nearly resembles ours, but I report here only what I saw. The mills were picturesque outside as well as inside. I did not actually see one with a thatched roof, but momentarily expected to. Several of the plants had been stripped of machinery by the Visitors. In one case the buildings had been turned into a factory for the production of wooden furniture for German dugouts, and I had the pleasure of sampling the product while we talked. The manager was in Germany trying to locate and identify his machinery, and the master mechanic expressed to me privately his hope that the wire benches would never be found.

Two things that characterize French wire drawing as I saw it are small bundles and wet drawing. The rods are frequently coppered directly after pickling and drawn wet to all sizes. The coating did not seem as red as our "high copper" finish, and it was only after persistent and repeated questions that I accepted the statement that it carried absolutely no tin. It drew off rather quickly to a straw color exactly like our tin-copper coat, and it seemed to me that it required rather frequent renewal.

The coarse wire is not drawn out of tubs, but is allowed to lie on a standard reel after having been dipped in a gummy looking mixture called "sauce," whose composition I could not make out, the ingredients being outside my small vocabulary. The coarse wire in bundles of 40 or 50 pounds runs out quickly and apparently has no time to rust. Fine wire is drawn from tubs of rye meal liquor, as with us.

The wire blocks down to 12 inches diameter have wide faces and generally no extension pins, since the bundles are too small to climb high. The reel serving the ripping block is generally on the floor, but for the other blocks the reels are mounted on the bench behind the blocks. It is not difficult to strip these light bundles, and to lean over and drop them onto the reel, just as in our fine wire practice. Germany supplies much of this wire drawing equipment. It is said that the German practice is more like our own, but that they seem quite willing to let France continue her wet drawing. I judge that the practice alone is enough to keep France out of the export market. In a good sized wire rope plant I found the usual practice to be two drafts from the rod in lime and soap to the first patenting point, then wet drawing to finished size. Kink tests on the process wire did not inspire in me any great respect for wet drawing.

The wire benches are of the types advertised by the various German manufacturers, generally with reels on the bench as described, and frequently with very close set blocks worked alternately from both sides of the bench. The drawout tongs are permanently attached to each block in a recess below the flange. The benches seem very light for their rating, and I found it was common practice to draw the first draft or two from the rod on horizontal spindle bull blocks. On these ripping drafts a speed of 10 to 15 rpm. of a 22-inch block was considered quite daring, with finishing speeds running anywhere from 25 to 40 rpm., and occasionally with small blocks as much as 50. Drafting is, of course, much lighter than in dry drawing, more drafts being necessary for a given reduction in the ratio of about 9 to 7.

This wet drawing practice brings out the interesting fact that in the reduction of soft steel our annealing practice is based less on the requirements of the metal than on the life of the coating. I observed more than once that the British with their carefully prepared coating were regularly drawing to finer gauge from the rod than we consider commercially practical. The French mills practicing wet drawing, and renewing the copper coat at frequent intervals, have no difficulty in reaching 20 to 22 gauge for nails or netting wire without annealing, and one manufacturer reported that 24 gauge was his usual practice.

Sulphuric acid is the usual pickling medium in France. I was unable to get an accurate comparison of their acid consumption with ours. The difficulty of discussing technical matters in an unfamiliar language may be readily understood. The writer became expert at transposing from kilograms per metric ton into pounds per net ton, at full conversational speed, but had to draw the line at applying correction factors for 53-degree acid, which was the best France could get in war times.

Continuous machines seem to be more used in France than with us, though not so common as in Great Britain. I found two large installations of Horton machines for both wet and dry drawing in all sizes. The machines were chiefly five-holers. Knowing this type of machine to be an American development, the French are under the impression that it is widely used here. The machines had water-cooled bronze seats and took nearly double the calculated power, the excess presumably going off in heat. They were kept in excellent condition and under careful manipulation showed production records that were really impressive. The following figures were reported to me by a prospective purchaser who had carefully checked the outputs in the plants of the "concessionaire." Though the information is not quite complete, it is accurate.

From	No. Drafts	To	Machines per Man	Output per Man
5	5	14	2	5700
..	5	15	2	4800
..	5	16	3	6000
..	5	16½	3	5500
..	5	17	3	4600
..	5	17½	3	4000
..	5	18	3	3300
15	3	18½	5	4400
15	4	19½	5	3100
15	5	21	5	2200
15	..	22½	5	1380
16	..	23½	5	1000
16½	..	25½	5	680
17	..	28½	5	500

NEW MERCHANT MILL PLANNED BY TENNESSEE COAL, IRON & R. R. CO.

Official announcement is made by George Gordon Crawford, president of the Tennessee Coal, Iron & Railroad Co., that a combination 10- and 12-in. merchant bar mill, two blocks long by 80 ft. wide and having a monthly capacity of 10,000 tons of plain or deformed bars, rounds and squares, is to be built at once at the works of the Tennessee company in Fairfield, a suburb of Birmingham. While the cost of the new mill has not been officially announced, it is stated unofficially that the figure will be approximately a million dollars.

The new merchant mill will be so located as to receive billets from the Fairfield blooming mill, to which tables will be added so that long billets can be delivered to the merchant mill without the necessity of switching cars. It will consist of a roughing train of six strands of 10-in. rolls, an intermediate mill of five strands of 12-in. rolls and a finishing train of two strands of finishing rolls, provided with 11-in. pinions, making it possible to use either 10-in. or 12-in. rolls.

A mechanical hotbed 255 ft. in length will receive the hot bars from the roll trains and, after cooling, the bars will be sheared and stocked in a stores and shipping room specially adapted for the storin gof concrete reinforcing bars and with storage capacity for a limited tonnage of merchant bars. The bar mill and stocking building will be 80 ft. wide and 820 ft. long. The capacity of the mills is estimated at 10,000 tons of plain or deformed bars, rounds or squares per month. The mill is to be built to care for the increased demands for bars in the Southern territory and for export. Material for the construction of the mill will be ordered at once and construction will begin as soon as the materials are received.

The New Continuous Strip Mill of the Trumbull Steel Company

A General Description of the New 14-in. Hot Strip Mill Which Will Be Ready for Operation About June 1—Capacity of New Mill 140 to 600 Tons per Day.

THE plant of the Trumbull Steel Company will be augmented about June 1 by a new unit which is designed to roll intermediate sizes of bands, hoops and strips varying from 2½ x .045 in. to 7 x .060 in. and thicker up to ¼ in. The finished product may be coiled or cut to lengths. This mill is an electrically driven, continuous mill with a continuous furnace heated by electric gas. The capacity of the new unit will vary from 140 to 160 tons per day, depending on the size of material rolled, and will fit in with the other mills of the strip department which consists of a 16-in. continuous mill, a 9-in. continuous mill, and a cold rolling department having 35 stands or rolls arranged single and in trains varying from two to four stands. The new mill was constructed by the Morgan Construction Company of Worcester, Mass., and is being erected by the steel company under the combined direction of Mr. Frederick Wille, consulting engineer of the Trumbull Steel Company, and the Morgan Construction Company.

Building.

This unit is housed in a steel building 1,200 ft. long and 100 ft. wide, consisting of 60 bays 20x100 ft. The roof is 1/5 pitch double monitor type with continuous sliding wood sash on the lower part and continuous louvres on the upper part. The roof truss elevation is 33 ft. above the floor line. This building forms a continuation of the 16-in. mill building parallel to the 9-in. mill building and the pickling building and is easily accessible to the cold rolling department. The building is served by two 15-ton cranes mounted on 60-lb. A.S.C.E. rails. One crane is a three-motor single trolley double hook type with 50-hp. bridge motor, 10-hp. trolley motor and 50-hp. mainhoist motor; the bridge travel speed is 40 fpm., the trolley travel speed 175 fpm. and the hoist-lift 30 fpm. The other crane is a four-motor single hook type with 10-ton auxiliary hoist, the auxiliary hoist motor is 30 hp. and the other features are similar to the first crane. The six bays at the north end of the building will be used for a billet yard and will permit the storage of three 30x60-ft. billet piles; 24 bays in the middle of the building will be devoted to the rolling mill with its furnace, motor-room, conveyors, etc., and the south half of the building will be used for the handling and storage of finished products.

Billet Yard.

The billet yard will be equipped with a 30-ton scale at the floor level, having 24-ft. platform and cradles for weighing billets and, also, with five cast iron billet skids which feed billets to charging conveyors. Dimensions: north end of building to first skid 143 ft. 5 in., from center line to center line of skids 6 ft. 8 in., center line charging conveyor to back of skids 17 ft. 8¼ in., floor line to top of skids (high end) 12¾ in.

Heating Furnace.

Morgan recuperative type of continuous heating furnace, using producer gas as fuel. This producer gas is developed in a producer gas plant situated west of the 9-in. mill; this plant serves both the 9-in. mill and the 14-in. mill furnaces. The producer gas plant is equipped with two Morgan and two Hughes gas producers. The heating furnace for the 14-in. mill has a Slick suspended roof, 11 cast iron water-cooled skids, magnesite brick on bottom of 4 ft. 6 in. inclined hearth and all of horizontal hearth. The air-exhaust is No. 9 monogram (Sturtevant) driven by 17½-hp. shunt wound motor. Dimensions: center line furnace to center line north end of building 210 ft., brickwork 34 ft. 2 in. wide by 37 ft. 2 in. long, center line of mill to discharge end of brickwork 6 ft. 2 in., center line of mill to charging end of brickwork 31 ft., width of hearth 32 ft., water-cooled skids 4 ft. wide by 7 ft. 7 in. long, spaced 2 ft. 7½ in. center to center, length of brick hearth 27 ft. 9½ in., 24 steel skids 2½ in. by 9 in. by 15 ft. long spaced 13½ in. center to center in brick hearth, slope of hearth 1:5, length of inclined hearth, measured horizontally, 22 ft. 5½ in., length of horizontal hearth 5 ft. 4 in.

The furnace has the following equipment: An external charging conveyor with an over-all length of 36 ft. 3½ in., supported by six cast iron stands having seven hollow cast iron rollers 15 in. in diameter by 18 in. long, which have a peripheral speed of 460 fpm.; from the face of furnace brickwork to center line of last roller 5 ft. 7½ in. and from floor line to top of rollers 7 ft. 11½ in. An internal charging conveyor consisting of five water-cooled rollers inside of the bearing furnace, with roll shafts inclined at an angle of 87 deg. with furnace and line of billet travel. The rollers of both the external and internal charging conveyors are driven by one 12-hp. dc. motor, the internal rollers being driven from the outside of the furnace by a line shaft and helical gears. Internal rollers are 8 in. in diameter by 14 in. long, the end 3½ in. of rollers tapering down to 6 in. in diameter. The peripheral speed of rollers is 96 fpm. Morgan type of cross pusher having five steel pusher arms, operated by cranks on line shaft which is operated by a bell crank connected to the piston of a steam cylinder, with the entire cross pusher bolted to furnace buckstays. Dimensions: pusher arms 1¾ in. by 5½ in. by 3 ft. 7 in., crank shaft 27 ft. 4½ in. long by 6 15/16 in. diameter, steam cylinder 25 in. diameter by 2 ft. 7 11/16 in. long. Hawthorne type of push-out rolls; over hand pinch rolls 11 3/16 in. diameter by 10 in. long with a peripheral speed of 330 fpm., driven through gear reduction by 12-hp. dc. motor. Pull-out rolls with rolls, roll drive and top roll lifting mechanism bolted to the furnace steel work; the bottom roll, which is 10 in. in diameter by 2 ft. 5½ in. long, is driven through spur gear reduction by 5-hp. dc. motor; the top roll lifting mechanism is operated through a worm reduction by a 2-hp. dc. motor. The top roll is 10 in. diameter by 2 ft. 8 in. long. The bottom roll has a peripheral speed of 89 fpm.

Roughing Mill Roll Train.

The roughing mill roll train consists of four stands of horizontal rolls with an emergency shear, three vertical edging mills and a flying shear arranged as follows: emergency shear, 16-in. edging mill, two stands or rolls, 1-in. edging mill, two stands rolls, 12-in. edging mill and flying shear.

The roll stands are two high with open top housings, top roll adjusting screw 4¼ in. diameter by 3 ft. 3½ in. long over all, four U. S. S. threads per inch; the bottom roll bearing is adjusted by wedges operated by screws on the side of the housings; the rolls are cast steel varying in diameter from 13.86 in. in the fourth stand to 12.54 in. in the first stand, length of body is 16 in., necks 10 in. in diameter by 13 in. long; wabblers are 9 in. in diameter by 5½ in. long.

The emergency shear is the Edwards up-and-down type which cuts at a rate from 7 to 29 strokes per minute; the knives are 18 in. wide, the upper one traveling 5 in. and the lower one 3 in.; this shear and the 16-in. edging mill are driven through a gear drive by a 140-hp. General Electric motor.

The fling shear is an Edwards steam operated type; the width of the knives is 10 in. and the diameter of the steam cylinder is 12 in.

The following dimensions apply to the roughing mill train: center line of roughing mill train to center line of west building columns 36 ft. 6 in., face of furnace brickwork to center line of emergency shear 5 ft. 6 in., floor line to center line of emergency shears 2 ft. 7 in., face of furnace brickwork to 16-in. edging mill 8 ft. 10½ in., center line of edging mill to center line first roll stand 4 ft. 7½ in., center line first roll stand to center line second roll stand 6 ft., second rolling stand to 12-in. edging mill 4 ft. 5¼ in., 12-in. edging mill to third roll stand 8 ft. 9¾ in., third to fourth 9 in.

Intermediate Roll Train.

This train consists of two stands of rolls, the fifth and sixth with the same roll housings as the roughing mill. The rolls are cast iron chilled to 13 in. in diameter and vary in diameter from 13.6 in. to 13.2 in.; all the other roll dimensions are the same as those of the roughing mill. From the center line of the fourth stand in the roughing train to the center line of the fifth stand in the intermediate train is 27 ft. 6 in.; from the center line of the fifth stand to the center line of the sixth stand is 9 ft. The two roll stands in the intermediate train are driven by a 1,250-hp. General Electric motor, which is connected directly to the sixth stand and to the fifth stand by a train of spur gears.

Finishing Mill Roll Train.

The roll housings of this train are the same as those of the roughing and intermediate roll mills. The rolls are cast iron clear chilled to 13 in. in diameter and vary in diameter from 14.4 in. to 13.6 in. The roll stands are spaced on their center lines as follows: from the sixth to the seventh 9 ft., from the seventh to the eighth 9 ft., from the eighth to the ninth 8 ft. 3 in., from the ninth to the tenth 7 ft. 6 in. The roll diameters in this train are so graduated that, when ground too small for one stand, a roll may be used in the next stand back. Each finishing mill stand is driven by an individual 800-hp. General Electric motor directly connected to the top pinion.

Equipment for Handling Finished Material.

Beyond the finishing roll train are guide troughs for guiding material to either the rotary shear or the vibrator; if the strip is to be shipped in lengths it goes to the rotary shear; if it is to be shipped in coils it goes to the vibrator. The guide trough to the rotary shear is straight and has an over-all length of 16 ft. 6½ in.; two widths are provided, 6 in. and 9 in.; they consist of two 8-in. side channel, 10 cast iron bottom plates and five steel cover-plates. The guide trough to the vibrator first twists the material to the vertical and then turns on a 10-ft. radius to an angle of 14 deg. and 18 min. and delivers material to pinch rolls at the vibrator.

Beyond the finishing mill train is a rotary shear designed to cut strip into lengths varying from 12 ft. to 30 ft.; this shear, which is placed 22 ft. from the center line of the tenth roll, is equipped with two knives 8 in. wide on each rotating shaft and is driven by a 4-in. double belt. Between the final belt and the line shaft are two belts running on four conical pulleys. The line shaft, which is used in common by the rotary shear and the vibrator, is driven by a 5-in. double belt running on a pulley on the tenth roll stand lead spindle. From the rotary shear a Morgan skelp conveyor carries the cut

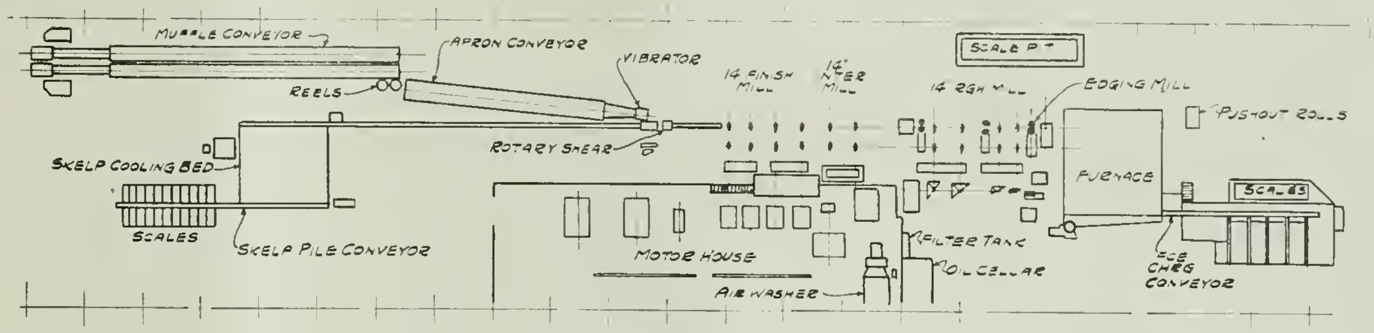


Fig. 1—General layout 14-in. hot strip mill.

lengths to the cooling bed which consists of 43 cast iron rollers 10 in. in diameter and 8 in. long. The rollers are fastened to 1 3/16-in. diameter shafts by two set screws; the peripheral speed of the rollers vary from 170 to 510 fpm.; this conveyor is belt driven through one gear reduction by a 10-hp. General Electric motor. Dimensions: center line rotary shear to center line double pulley 4 ft. 5 in., double pulley to first roller 15 ft., center line to center line of rollers 2 ft. 6 in., floor line to top of first roll 2 ft. 8½ in., floor line to top of last roll 5 ft. 2 in. The conveyor terminates in two piling rolls 10 in. in diameter by 8 in long, with a peripheral speed varying from 246 to 738 fpm.; from the center line of the last table roller to the center line of piling rolls is 4 ft. 4 in.; the piling rolls are driven by a 5½-hp. General Electric motor.

The cooling bed is a Morgan skelp type with reciprocating dogs. From the center line of the rotary shear to the cooling bed is 116 ft. 2 in.; the width of the cooling bed from the center line of the skelp conveyor to the center line of the pile conveyor is 28 ft. 5 in.; the length is 30 ft. 6 in. There are eight lines of dogs spaced 16 in. apart with a stroke of 18½ in.; the stroke of the skelp conveyor kick-off is 22⅛ in.; the dogs and kick-off are operated through clutches from the same gear reduction driven by a 20-hp. General Electric motor. Piles of cut lengths are tied before leaving the cooling bed.

The pile conveyor conveys the tied piles to twin scales; this conveyor consists of 13 cylindrical rollers 15 in. in diameter by 12 in. long, and 11 double conical rollers 13 in. long with 15-in. center diameter and 10¾-in. end diameters. The double conical rollers are arranged to dump on either side on the twin scales; their peripheral speed is 66 fpm.; they are belt driven from a drop pulley driven through worm reduction by a 10-hp. dc. motor. From the center line of the cooling bed to the center line of the scales is 31 ft. 9 in. The scales have a capacity of 30 tons; their platforms are 30 ft. long and there are 11 cast iron storage bins for each scale.

From the guide troughs material which is to be shipped in coils goes to the vibrator; this is a device for distributing strip in a serpentine form upon an apron conveyor. Strip is driven through the vibrator by two pinch rolls 14 in. in diameter by 5½ in. long, having peripheral speed varying from 1130 to 2260 fpm. The vibrator itself may have from 110 to 220 vibrations per minute with variable lengths of vibrations; it is driven by an eccentric, which in turn is driven by a belt from the same line shaft as the rotary shear. From the center line of the tenth roll to the center line of the vibrator is 30 ft. 3½ in.; from the center line of the mill to the center line of the vibrator is 3 ft. 10 in. The apron conveyor takes the strip in a serpentine form from the vibrator to the reels and acts as a cooling bed; it is driven through a reduction gear by a 10-hp. dc. motor. Dimensions: vibrator to foot shaft 10 ft. 3 in., foot shaft to head shaft 70 ft. 1½ in., floor line to top of conveyor at foot shaft 2 ft. 4¾ in., at head shaft 2 ft. 1 in. At the head shaft of the apron conveyor are two reels for coiling the strip; these reels have collapsible cores raised and lowered by link crank rod and eccentric driven by individual 15-hp. dc. motor. The reels themselves are driven by individual 15-hp. dc. motors, with speed varying from 72 to 288 rpm. and are equipped with a pull-over device for transferring coils to the muffle conveyor; this pull-over consists of a 1¼-in. square bar 14 in. long suspended by I-beam monorail and having a dog on one end to hook coils; this bar is driven forward and back by motor operated pinch rolls with a speed of 30 rpm.; the pinch rolls are driven through worm reduction by 12-hp. dc. motor. Dimensions: center line of vibrator to center line reels 88 ft. 9 5/16 in., center line mill to center line 4 ft. 6 in., diameter of collapsible cores 20½ in., diameter of revolving top 3 ft. 9 in., diameter of pinch rolls 9½ in.

Two muffle conveyors of the chain and dog type, located side by side, receive coils from reels and convey them through a partially deoxidized atmosphere and deliver them to trucks; the muffle effect is secured by water-cooled covered plates. At the end of main conveyor, short inclined chain conveyors lower the coils onto trucks; each conveyor is driven through gear reduction by a 12-hp. ac. motor. Dimensions: center line reels to the nearest conveyor 4 ft. 9 in., conveyors center line to center line 5 ft. 9 in., center line conveyors to center line of building columns 12 ft. 2½ in. Speed of chain 350 fpm. Length of conveyor, center line of reels to center line of head shaft, 116 ft. 4 3/16 in.

Motor-Room.

The motor-room is located in the mill building on the east side, 260 ft. from the north end columns with a length of 140 ft. and a width of 43 ft. 9¾ in. The walls are brick and the roof is of corrugated sheeting, removable to admit crane hooks into motor-room. All mill driving motors, two 2,300-kw. motor generator sets, exciter, and a Spracco air washer are in the motor-room.

Electric Equipment.

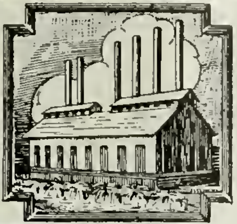
The electric equipment is all furnished by the General Electric Company. The roughing stand and the intermediate stand are driven by two 1,250-hp. 175-350 rpm. dc. motors. The last four stands, which constitute the finishing mill, are each driven by 800-hp. dc. motors, with speed varying from 200 rpm. to 250 rpm. These motors obtain their power at 600 volts, dc., from two motor generator sets, type MCF 12, 450 rpm., 600 volts, 2,300 kw. compound wound, each driven by a 3,300-kva. 450-rpm. 220-volt motor.

CORROSION OF FERROUS METALS

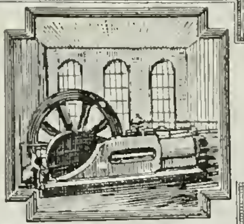
A paper was read before the Institution of Civil Engineers, in which the author, Sir Robert A. Hatfield, referred to tests made with fourteen different types of ferrous metals. They included irons (rolled and forged), carbon steels, special steels, and cast irons, and were represented 1,330 separate specimens, 24 in. x 3 in. x ½ in.

The tests were carried out on a total number of 182 test-pieces, and particulars of the tests are given. The nature, chemical composition and other qualities were discussed, and in the case of non-rusting steel, the resistance to corrosion, when constantly wetted by sea-spray, depends upon its physical constitution.

The author discussed the various theories of corrosive action, and the addition of copper to steel, for the purpose of preventing or mitigating corrosion, was not generally advised. Examples were given of special steels possessing great resistance to corrosion, and specimens of historical interest were described.



STEAM POWER DEPARTMENT



Wheeling Steel Corporation Construct New Power Plant

A Detailed Description of the Modern Power Station Constructed at the Whitaker-Glessner Plant, Wheeling, W. Va.—Many Unusual Features Mark the Plant.

By THOS. G. ESTEP
Associate Professor Mechanical Engineering,
Carnegie Institute of Technology

A NEW power plant has recently been put in operation at the Whitaker-Glessner Plant of the Wheeling Steel Corporation at Wheeling, West Virginia. Engineers are always interested in how others have solved their problems but a description of the plant should prove doubly interesting to the profession on account of its many unusual features.

At the present time, and for some time past the mills of the Whitaker-Glessner Company have been undergoing complete reconstruction for the purpose of making them more modern and efficient and to greatly increase their capacity, the product being chiefly sheets and black plates.

This rebuilding and increase in capacity has made a new power plant necessary and the engineering features entering into its design and construction are based on the years of experience of the company engineers in meeting the needs for power, light and heat for this branch of the steel industry.

Location.

When a plant is located in a river town like Wheeling, one would naturally expect to find it situated on the river bank so as to secure all the advantages of a navigable stream; such as an abundant supply of water and water transportation for fuel. But this plant is some distance from the river—in fact—far enough away so that no benefits are derived from the stream. There are two reasons for this. First, due to railroads, etc., no space was available along the river bank. Although this first reason is conclusive enough, the second is equally good, viz., that the company has its own coal mine, the drift mouth being in the hillside above the boiler house. The advantage of having the coal delivered in the mine cars directly from the pit mouth to the coal crusher far outweighed any advantage that might be secured from a location near the river, particularly when, for the present, the plant is to be operated non-condensing.

The site selected also has the advantage of being centrally located with respect to the mills so that long steam and transmission lines are avoided.

A part of the hillside, which is very precipituous, had to be removed to provide space for the buildings, and since this involved solid rock excavation, every possible advantage was taken of the topography in establishing the floor lines so as to have as little excavation as possible. A glance at the section in Figure 2 shows how this idea was carried out.

Buildings.

All the buildings are of steel frame work covered with corrugated galvanized iron. Practically all of this plant was constructed during the highest of the war prices, and although a brick building had been originally contemplated and designed, the cost at that time proved prohibitive and the cheaper construction was resorted to. The design is such, however, that the brick walls can be built at any time without any interruption to the operation of the plant.

The boiler room is 143 feet long and 58 feet wide with basement. The engine room is 100 feet long by 52 feet wide and is also provided with basement. The electrical repair shop which is under the same roof as the engine room and served by the same crane occupies a space 43 feet by 52 feet.

Boilers.

The boiler room contains four Connelley boilers having 8,290 square feet of effective heating surface and designed for a working pressure of 200 pounds per square inch gauge. The boilers are of the standard type with the standard location of baffles. An interesting feature in connection with the baffling is the method of supporting the middle pass baffle. Instead of this resting on the regulation cast iron frame, a piece of extra heavy pipe has been substituted, which is patented, the ends of this pipe being open and extending out through the boiler walls. The free air circulation through the pipe prevents overheating and warping. If necessary, one end of the pipe can be carried up towards the top of the boiler, this producing a stack effect and securing more rapid air circulation.

The baffle openings are shown in figure 2 and are arranged to give best results when the boilers are operated at from 150 to 175 per cent of their rated capacity.

Boilers numbers 1 and 2 are fitted with Westinghouse underfeed stokers having 8 retorts per boiler. The stoker drive consists of two Westinghouse engines arranged so that either engine can drive the two boilers, either separately or combined, thus insuring maximum flexibility. The stokers have an actual grate area of 153 square feet and a projected area of 142 square feet. This corresponds to a grate surface ratio of 54 and 58.3 respectively. The boilers are set well above the grates, the center line of the mud drum being 8 feet above the dump grates. This gives a furnace volume of about 2.2 cubic feet per rated horse power of boiler.

One boiler is equipped with the Drake non-clinkering furnace lining which has proven very satisfactory. The boilers, however, have not as yet been operated at high rating for any great length of time.

Each boiler is equipped with a Foster Superheater having 1064 square feet of superheating surface and designed to give 100 deg. F., superheat at 200 pounds per square inch gauge pressure, when boilers are operating at 100 per cent of their rated capacity and the moisture in the steam does not exceed one per cent. This corresponds to a total steam temperature of 488 deg. F.

All boilers are fitted with Vulcan soot blowers, there being seven elements in each boiler. In addition to the regular cast iron sheathing, the elements located in the first pass are further protected from the high temperature gases by tile baffles.

The boiler settings are all covered with "Evertite" a plastic material used to prevent air leakage.

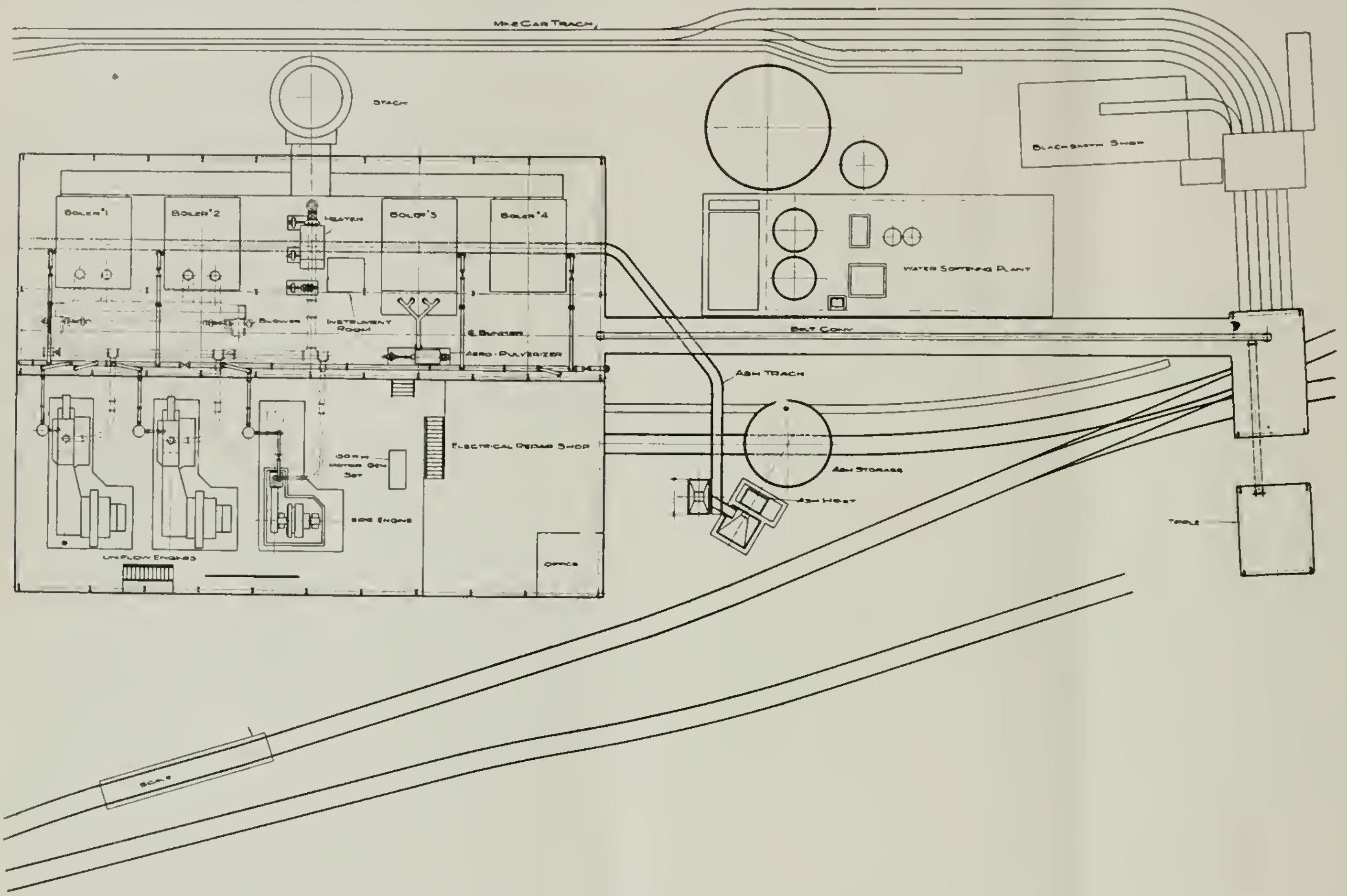


Fig. 1—Plan view of plant showing location of mine tracks, coal tipple, water softening plant and ash storage in relation to main plant.

Boiler number 4 has not been bricked in as yet, pending the results of the experiments with powdered coal now being conducted on boiler number 3.

There were no exceptional engineering considerations which lead to the selection of the above mentioned type of boilers, stokers and superheaters. At present the load on the plant is not very heavy and the system of operation is to operate one boiler continuously at from 150 to 175 per cent of its rated capacity and take care of the fluctuations in the load on the other boiler.

With number 4 boiler eventually bricked in and equipped with either powdered coal or a stoker, the capacity of the boiler plant will be sufficient to take care of the requirements for several years, with one boiler as a spare. No especial provision was made for extending the boiler plant in the near future as this is not contemplated.

Feed Pumps and Heaters.

A space between boilers numbers 2 and 3 was provided for the location of the boiler feed pumps, water heater and instrument room.

There are three Frederick centrifugal boiler feed pumps, direct connected to 50 horsepower Terry turbines. They have a capacity of 150 gallons per minute when operating at their normal speed of 2,800 rpm. Each pump can take care of about 2,500 boiler horsepower (maximum) so that two pumps will provide for about 200 per cent of the rated capacity of the three boilers. Conditions of operation are such that it is expected to have one pump in reserve at all time.

In the summer months all the exhaust steam from the engines and auxiliaries goes through the open heater. In the winter exhaust steam is used for heating the various parts of the power plant, the excess going to the heater.

Draft Apparatus.

Forced draft for the Westinghouse stokers is furnished by two turbine driven fans, operating at 1,700 rpm, the turbines being furnished by the Westinghouse Company and the fans by the Green Company. During the summer months the fans take air directly from the fan room, but in the winter when the fan room must be heated, the air for the fans is taken from the outside, a single suction duct serving both fans.

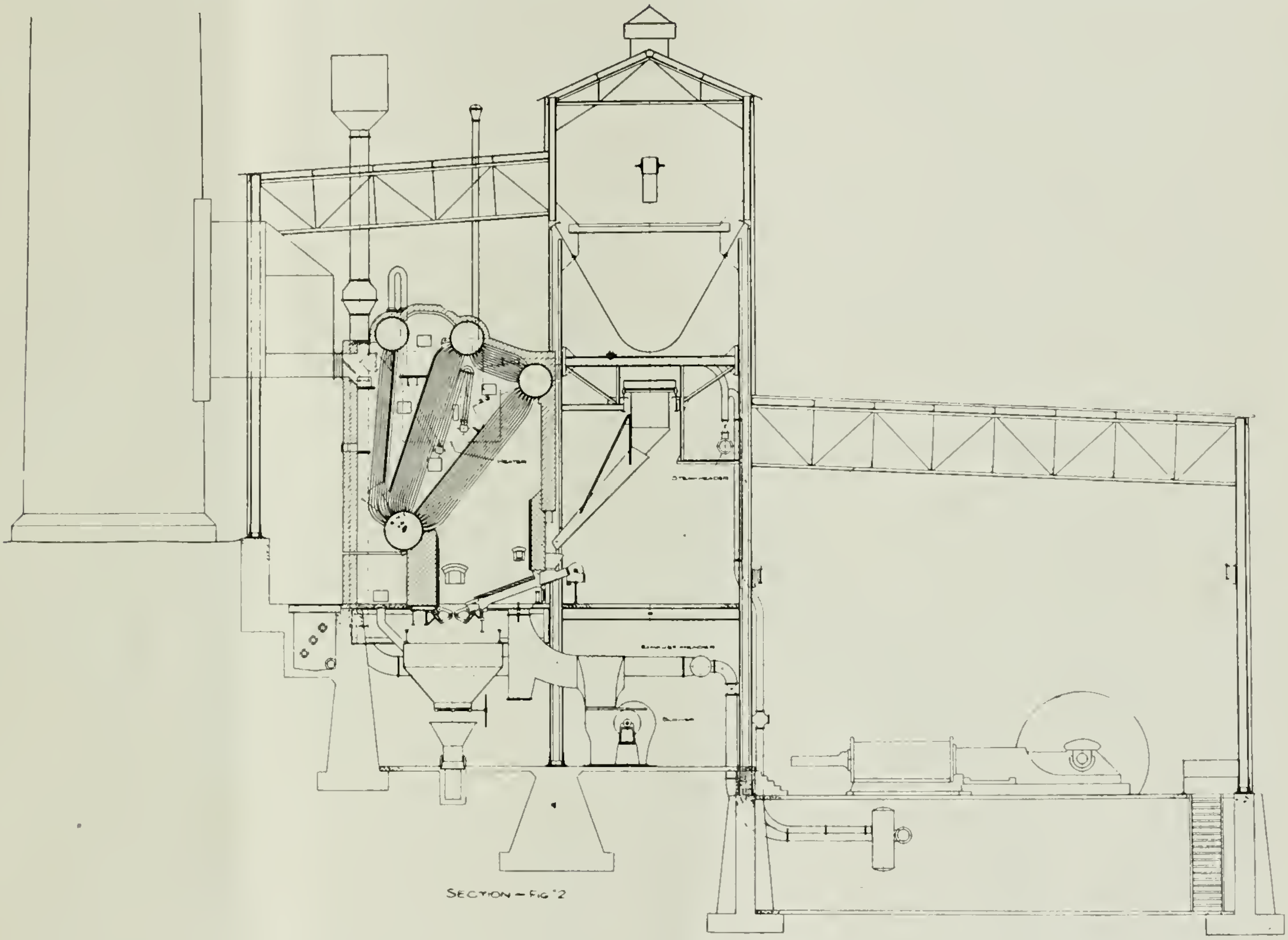


Fig. 2—Cross section showing how advantage was taken of the topography in establishing floor levels.

Each fan has sufficient capacity for two boilers and they are connected in such a way that either fan can serve either boiler or both boilers.

Space has been provided for the installation of two similar units for boilers numbers 3 and 4 for which stokers have been purchased, however, if the powdered coal turns out as anticipated two of the stokers will not be installed. Natural draft is furnished by a brick chimney 14 feet inside diameter at the top and about 200 feet high above the grates. The chimney was built by the H. R. Heinicke Company. The plan view of the plant shows the location of the chimney with reference to the plant.

A Cochrane combined open feed water heater and "V" notch weir having a capacity of 225,000 pounds of hot water per hour is located directly above the feed pumps so that there is always a positive suction head of approximately 14 feet. The capacity of the heater is such that it will exactly supply the three feed pumps?

Installed in the main exhaust header line which is 24 in. in diameter is a Klipfel back pressure valve which is to be used for regulating the pressure to the Skinner heaters and the water softening plant for heating purposes. In the vertical line leading to the heater is a Cochrane multiport back pressure valve set so that the back pressure at the engine is about a pound or a pound and a half, just enough to force the steam to the heater.

Coal and Ash Handling.

The coal and ash handling equipment was furnished by Webster Manufacturing Company.

The coal comes from the pit mouth to the coal tipple in the mine cars and is dumped onto a screen, the fine coal going directly to an apron conveyor, the lump coal passing to a two roll Heyl & Patterson motor driven crusher and thence to the apron conveyor. This conveyor discharges the coal on the belt conveyor which carries it up and into the coal bunker.

The coal handling equipment has a capacity of 60 tons per hour. The belt is 18 inches wide and about 670 feet long. It travels at the rate of 250 feet per minute and rises 3⅞ inches in 12 inches or an angle of about 18 deg. The total rise of the belt conveyor is about 50 feet. The bunker, which is steel, bitumastic lined, has a capacity of 700 tons and by doing some hand shoveling the capacity can be increased to 800 tons.

The coal is spouted from the bunker to a traveling weighing hopper where it is weighed and the weight recorded. After weighing the coal is spouted to the stoker hoppers.

The ash and clinker from the boiler furnaces drop into a fire brick lined cast iron hopper provided with a water sprinkler which can be operated either from the boiler room or ash tunnel floor level. This ash hopper is provided with poke holes and explosion doors.

The ash drops through a hand operated gate into a side dump buggy which holds one cubic yard. This buggy is then taken out through the ash tunnel into the yard by means of a Mercury electric locomotive operated by storage batteries and the ash is dumped into a pit covered by a coarse grid with 12-in. square openings. The ashes then pass from this pit through a hand operated gate into the skip hoist, having a capacity of 40 cubic feet, which delivers them into an ash storage bin of 5,900 cubic feet capacity, from which they can be spouted into railroad cars.

The cross section of the boilers shows a duct leading from the duct space back of the bridge wall to the boiler ash hopper. This is a circular duct and is closed at the top by a hollow 14 in. cast iron ball which can be rolled aside and the dust removed. When the ball is in place air leakage is prevented when ashes are being removed from the hopper.

Water Softening Plant.

The water softening plant was furnished by the International Filter Company and has a capacity of 27,000 gallons of treated water per hour.

Water from the city mains, which is untreated river water, is first treated with alum in the coagulating

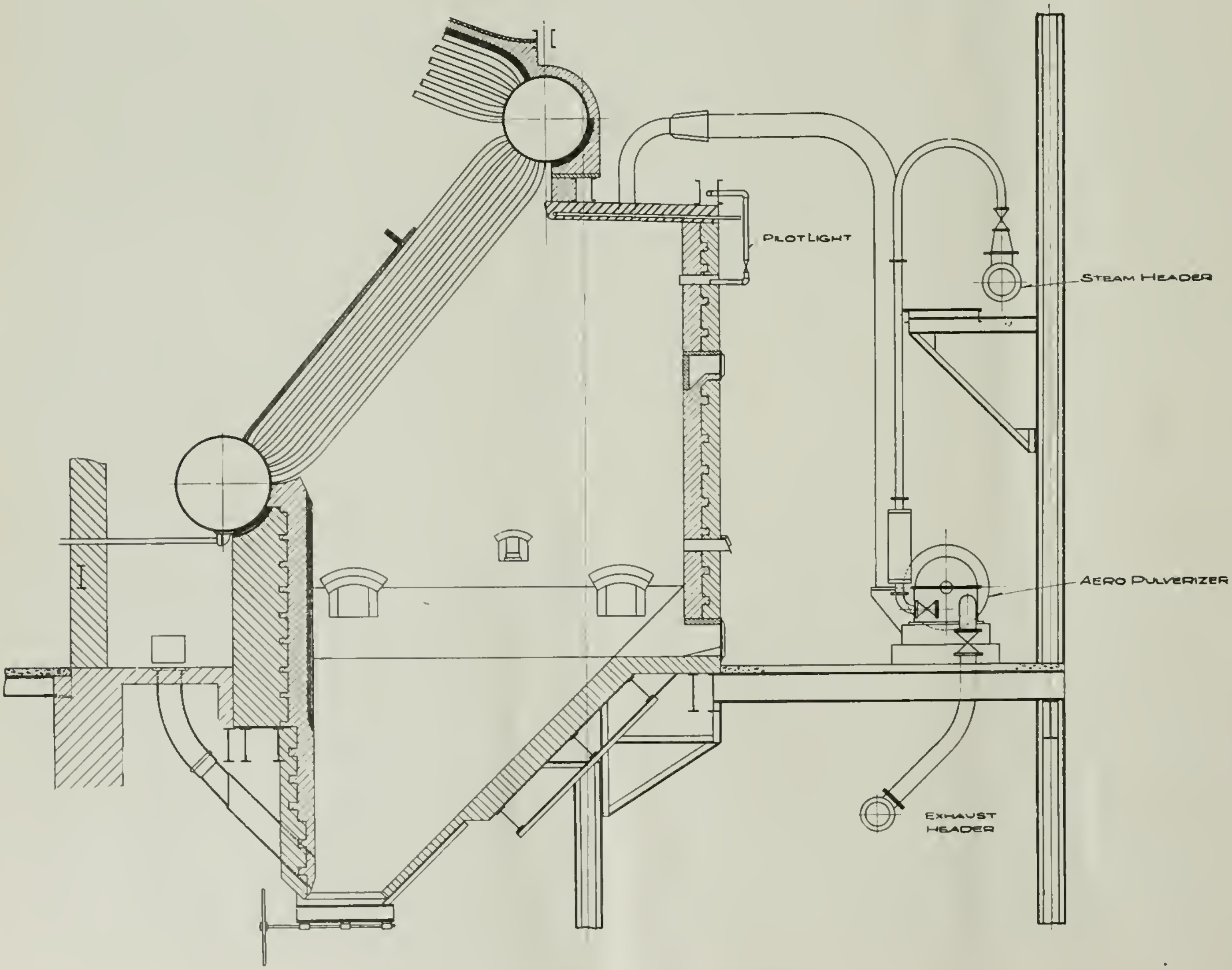


Fig. 3—Cross section of pulverized coal furnace.

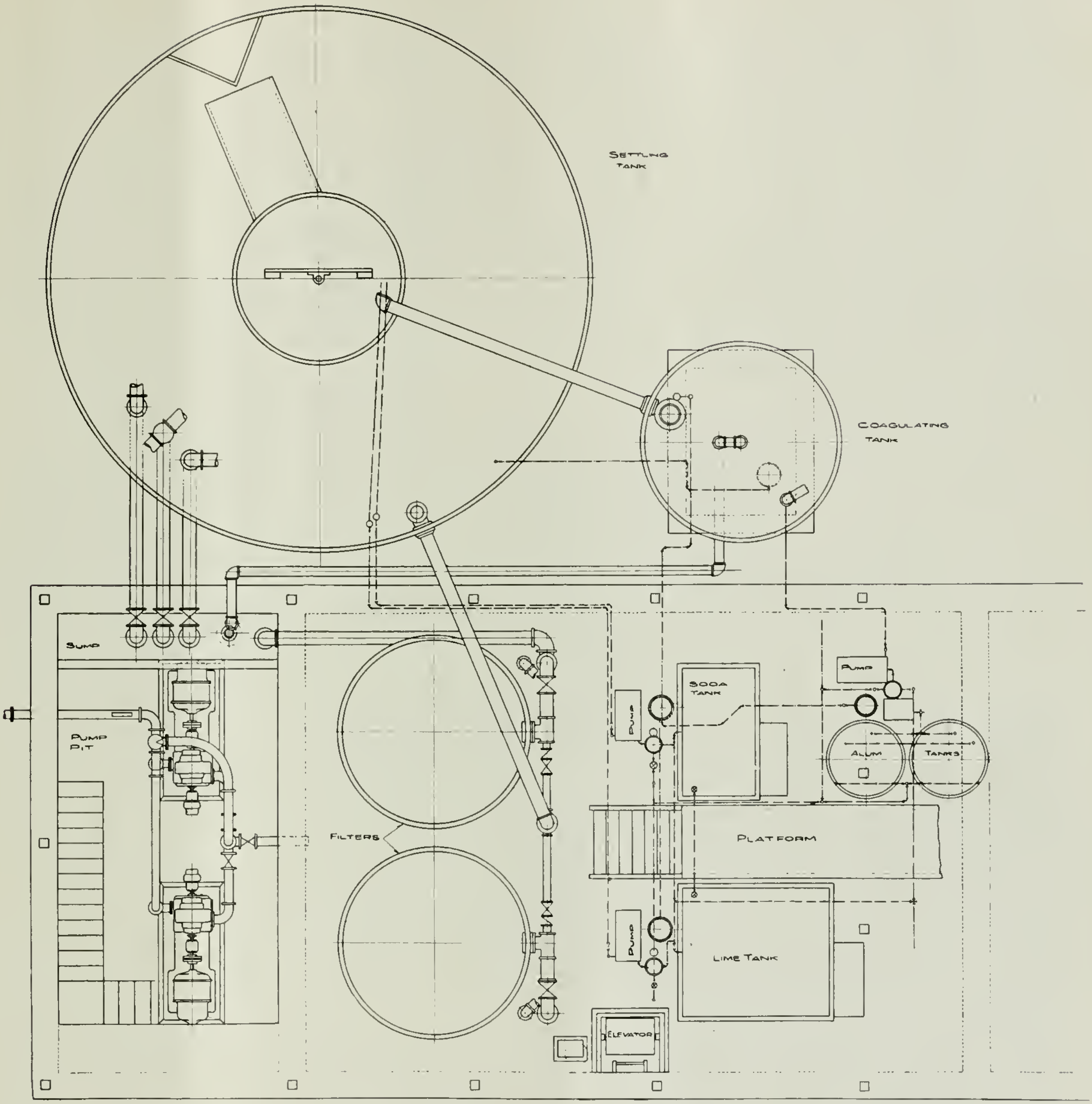


Fig. 4—Plan view of water softening plant.

tank which is 11 feet diameter and 22 feet high. The water from this tank is then treated with lime and soda and passes to the settling tank which is 30 feet diameter and 22 feet high. Water then passes from the settling tank through sand filters to the clear water basin which forms part of the softening plant foundation. The clear water basin has a capacity of 52,000 gallons.

In a pit at the base of the clear well are installed two motor driven 2 stage Worthington centrifugal pumps having a capacity of 300 gpm. each. These pumps are supplied under a positive suction head and deliver the water to the feed water heater, or when the heater is being cleaned or repaired, direct to the boiler feed pumps. Since the clear water pumps have a capacity of 300 gpm., one is held in reserve.

The entire operation of the filtration plant is automatic. Tests of the treated water are made twice daily and changes made in the strength of the chemical solutions accordingly, but the proportioning of the solutions to the water is entirely automatic. The treatment is intermittent, a new batch of water being treated automatically as needed.

A small electric elevator is used to bring the chemicals from the car at the yard level up to the mixing platform. As the plan and sections of this softening plant show, every advantage was taken of the topography.

It proposed to install a 50,000 gallon storage tank on the hillside above the boiler room. The clear water centrifugal pumps will deliver water to this tank and will be controlled by a float so that their operation will be intermittent but at full capacity instead of continuous at reduced capacity as at present. The treated water will then flow by gravity from this new storage tank to the heater or boiler feed pumps.

Powdered Coal.

At the present time powdered coal for boilers is receiving a great deal of attention from the engineering profession so that a description of what is being done along this line at this plant will no doubt prove very interesting.

Figure 3 shows a cross section of number 3 boiler as it is now equipped for the burning of powdered coal. It must be understood that this work is in the experimental stage and that the final arrangement may differ greatly from the present scheme.

The front wall of the boiler has been moved out about five feet in order to provide a large combustion chamber, giving a volume of over 5 cu. ft. per rated hp of boiler.

At the top of the combustion chamber is a water cooled flat suspended arch which is patented. Powdered coal along with the air for combustion is admitted through this flat arch in four places as shown, the fuel being directed vertically downward.

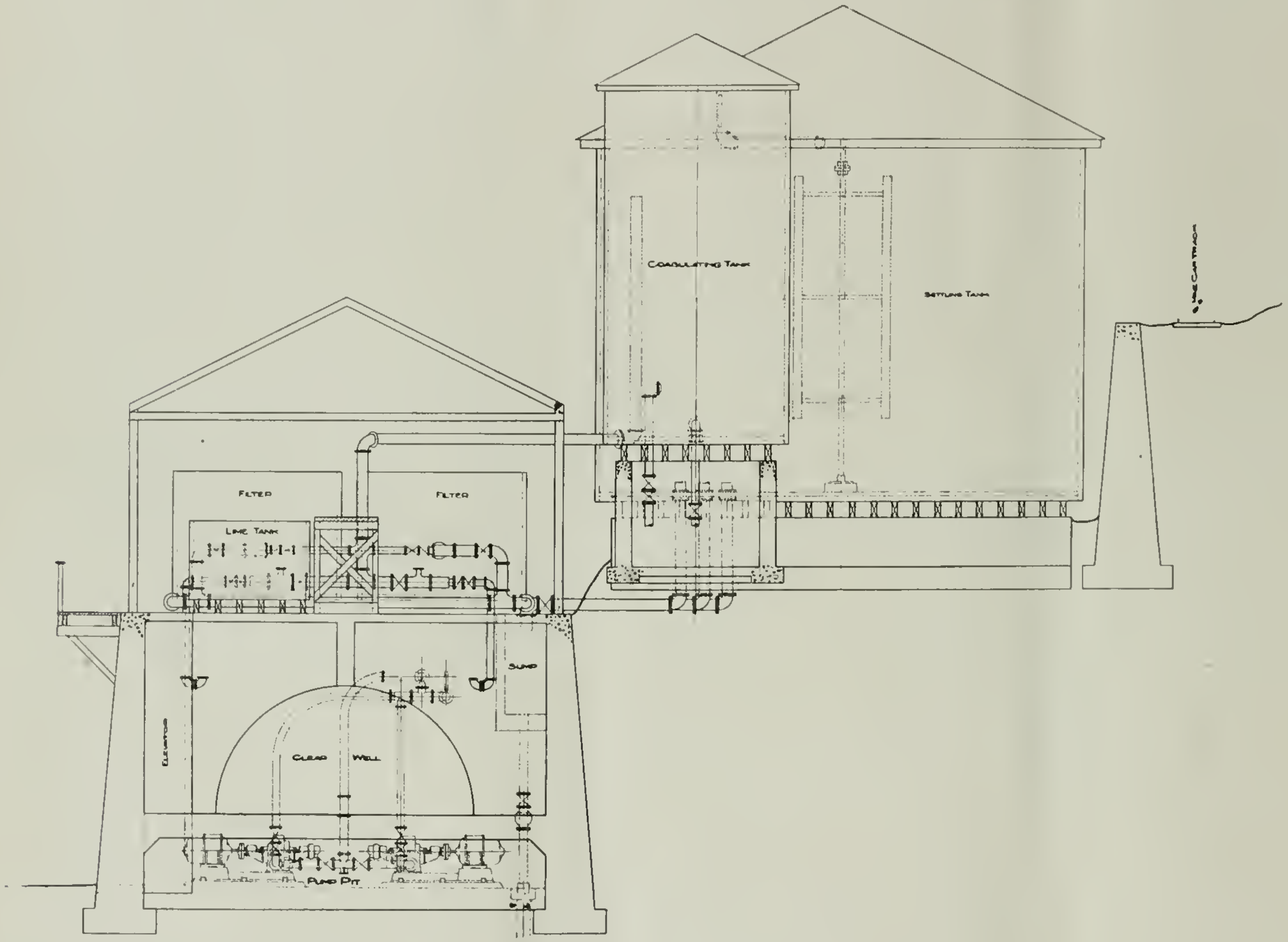


Fig. 5—Section of water softening plant.

The foundation of this boiler was built to receive a Westinghouse stoker so that the bottom of the combustion chamber was made to conform to this and no especial significance is attached to its shape.

Coal is spouted from the bunker to a size G Aero pulverizer having a capacity of 6,000 pounds of coal per hour. The pulverizer is driven at 1,450 rpm, by a Westinghouse turbine.

The coal from this pulverizer rises vertically in a single duct, passes over to the top of the boiler and enters through four branches.

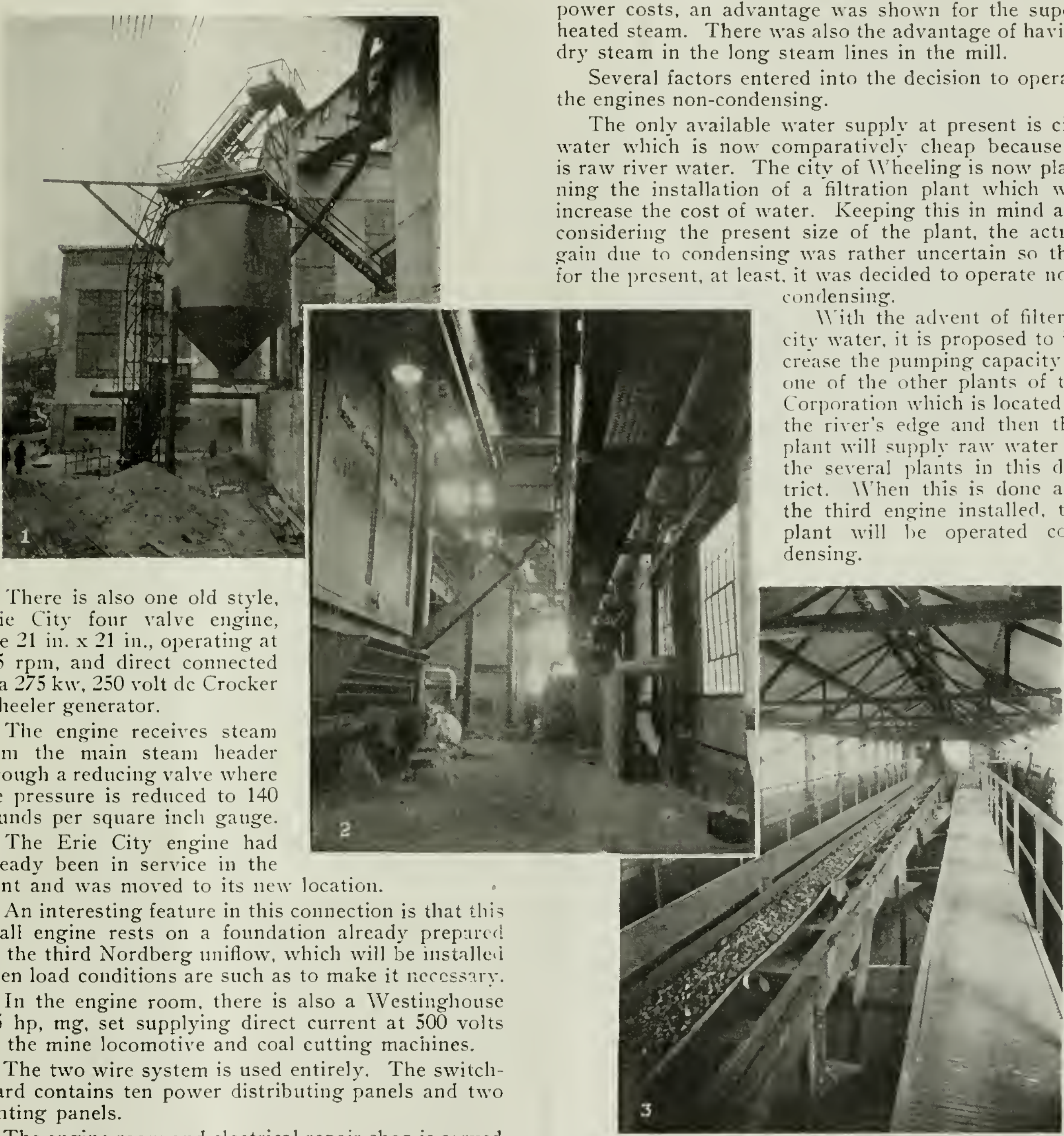
In starting up the boiler, ignition is accomplished by using natural gas.

As before mentioned, this installation is still in the experimental stage and the work which has been done so far was of a preliminary nature so that no test data are available.

So far the performance has been, in general, very satisfactory. No serious trouble has resulted from slaging, the capacity secured from the boiler has been high and judging from flue gas temperature and analysis the efficiency is high. Minor details in the technique are being solved at present and it is hoped that test data may be available later to the readers of Blast Furnace and Steel Plant.

Engines.

The engine room contains two 24 in. x 42 in. Nordberg uniflow engines operating at 125 rpm, and direct connected to 600 kw dc Westinghouse generators operating at 250 volts. These engines receive steam at 200 pounds per square inch gauge pressure superheated 100 deg. F., and exhaust against a back pressure of 2.5 pounds per square inch gauge.



Figs. 1-2-3—General views of Webster Manufacturing Company's coal and ash conveyor system installed in the Wheeling plant.

There is also one old style, Erie City four valve engine, size 21 in. x 21 in., operating at 185 rpm, and direct connected to a 275 kw, 250 volt dc Crocker Wheeler generator.

The engine receives steam from the main steam header through a reducing valve where the pressure is reduced to 140 pounds per square inch gauge.

The Erie City engine had already been in service in the plant and was moved to its new location.

An interesting feature in this connection is that this small engine rests on a foundation already prepared for the third Nordberg uniflow, which will be installed when load conditions are such as to make it necessary.

In the engine room, there is also a Westinghouse 225 hp, mg, set supplying direct current at 500 volts for the mine locomotive and coal cutting machines.

The two wire system is used entirely. The switchboard contains ten power distributing panels and two lighting panels.

The engine room and electrical repair shop is served by a 10-ton hand operated crane.

Located in the steam line near the uniflow engines are large Cochrane receiver separators having a volume of about six times the piston displacement.

The main steam line to each engine is provided with a quick closing electrically operated Falls-Engine-Stop which is closed automatically by over speeding and can also be closed by push buttons conveniently located.

The considerations leading to the selection of uniflow engines instead of turbines or duo-flow engines was largely a matter of the final cost of power.

Whether superheated steam was to be used or not was decided by using guaranteed water rates for both saturated and superheated steam and figuring final power costs, an advantage was shown for the superheated steam. There was also the advantage of having dry steam in the long steam lines in the mill.

Several factors entered into the decision to operate the engines non-condensing.

The only available water supply at present is city water which is now comparatively cheap because it is raw river water. The city of Wheeling is now planning the installation of a filtration plant which will increase the cost of water. Keeping this in mind and considering the present size of the plant, the actual gain due to condensing was rather uncertain so that for the present, at least, it was decided to operate non-condensing.

With the advent of filtered city water, it is proposed to increase the pumping capacity at one of the other plants of the Corporation which is located at the river's edge and then this plant will supply raw water to the several plants in this district. When this is done and the third engine installed, the plant will be operated condensing.

Instruments.

The electrical switchboard is equipped with the usual indicating and totalizing instruments.

Each boiler is equipped with the Bailey Boiler Meter giving the steam flow, air flow and stack temperature on the one chart. In addition two porcelain scales are provided upon which are indicated the steam flow and furnace draft. This instrument is mounted directly on the boiler front for the use of the fireman.

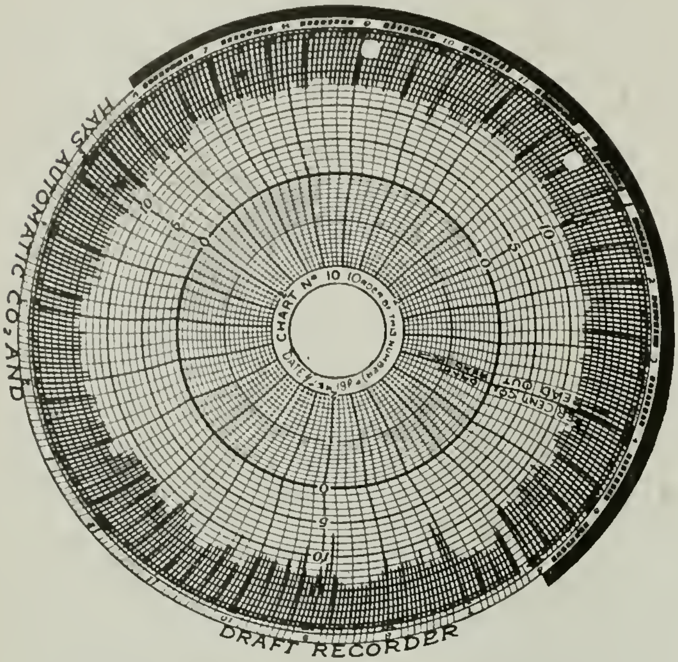


Fig. 9—Chart from the Hay's CO_2 recorder connected to one of the stoker fired boilers. Note the uniformity of the CO_2 content which indicates that the boiler is well managed.

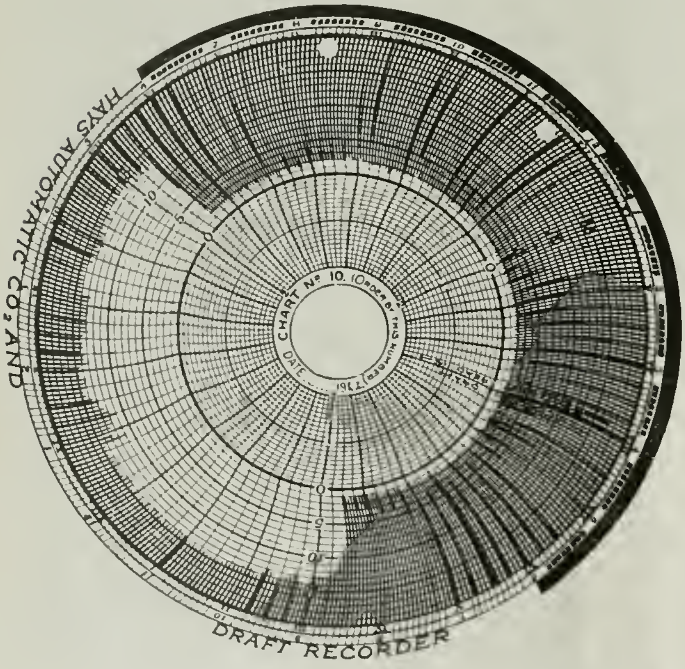


Fig. 10—Chart from the Hay's CO_2 recorder connected to the powdered coal fired boiler. The CO_2 content in addition to being high shows an average variation of only about one per cent which indicates remarkably efficient control.

An instrument room has been built in the boiler room in the space between boilers numbers two and three. Located in this room are the usual recording thermometers and pressure gauges.

The Hays carbon dioxide recorders are used, one recorder for each boiler.

Republic steam flow meters are used on the steam distribution lines to the engines and mills.

To secure satisfactory operation of the flow meters on the lines to the reciprocating engines, where there is a pulsating flow, a thin plate orifice, having an area of 80 per cent of the area of the steam line was placed between the special pitot tube and the engine. This orifice, along with the large receiver separators reduced the pulsations enough to make reasonably accurate measurements possible. The indicating and recording devices of the Republic meters are also located in the instrument room.

The Carrick Combustion Control is used on all of the boilers. This control is actuated by a change in the steam pressure and varies the speed of the stoker engine, the position of the boiler damper and the amount of air supplied by the forced draft fans. This latter quantity is changed by a damper in the air duct rather than by changing the fan speeds.

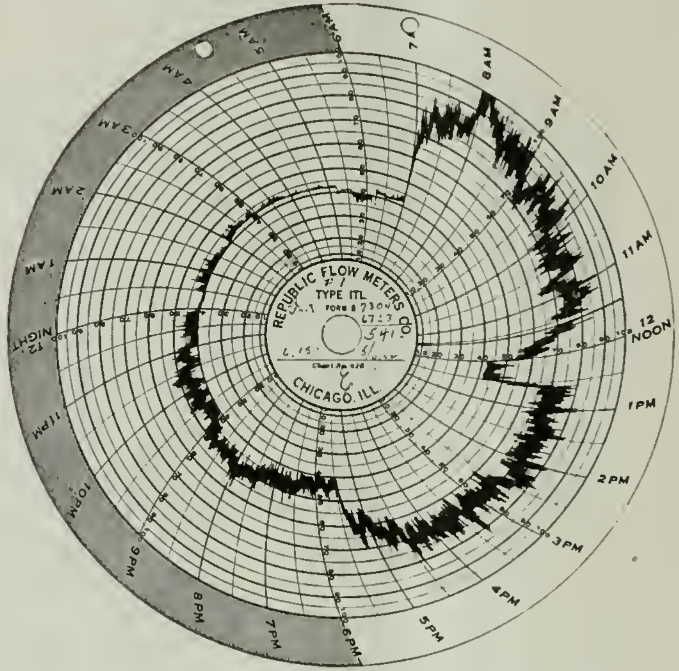


Fig. 11—Chart from the Republic Flow Meter on the main steam line to the Uniflow engine. This engine carries a fluctuating load which accounts for the width of the record line. By the use of a throttle disc and a large receiver, pulsations have been almost entirely eliminated.

It was felt that better economy could be secured by operating the turbine at constant speed and varying the load than by changing the speed.

The method of control of the boiler burning pulverized coal may prove interesting. An auxiliary regulator actuated by the main regulator control dampers in the air supply to the pulverizer. This auxiliary regulator also controls the supply of pulverized coal by regulating the speed of the coal feeder. Another regulator, actuated by the furnace pressure, controls the breeching damper, maintaining a constant negative pressure in the combustion chamber.

Piping.

The piping layout was made by the company engineers and erected by the American Foundry and Construction Company. Bends were used whereever possible instead of fittings and Van Stone joints were used throughout. The covering was all done by the Johns-Manville Company.

There is one commendable feature in connection with the piping. There are no valves or fittings which cannot be conveniently reached, either from the floor or a gallery. The writer does not recall seeing a plant as well equipped with galleries as this one.

All drips and drains are taken care of by Bundy traps discharging back to the feed water heater.

An interesting feature in connection with the steam traps is that their operation was not entirely satisfactory at the full main pressure of 200 pounds per square inch, so that reducing valves were installed in the main drain headers where the pressure is reduced to 75 pounds per square inch. The traps now operate very satisfactorily.

All of the piping is painted, a definite color scheme being carried out so that the piping can be readily identified.

In putting this plant in operation it has been remarkably free from the various troubles incident to a new plant which only goes to show that a great deal of care and consideration was given to the selection and installation of equipment.

In conclusion, it might be interesting to note that a Nordberg twin uniflow engine has just been installed in the tin plate mill serving six stands of rolls. The engines are exact duplicates of the ones in the power plant, all of the parts being interchangeable.

Progress in Pulverized Fuel Firing

Code Recommended for Adoption by the Carnegie Steel Company in the Handling of Pulverized Coal Presented—Many Points of Unnecessary Danger Have Been Eliminated.

By F. J. CROLIUS
Steam Engineer, Carnegie Steel Company, Homestead Works

PULVERIZED fuel firing is moving forward steadily. The progress now being recorded will be permanent—as each year places a firmer foundation under existing knowledge structure; facts deduced from experience have taken the place of theories developed in enthusiasms.

Many claims have been made for the advantage of fuel fired in suspension over fuels fired in solid form, and not enough stress was laid upon certain disadvantages which were found to develop where excess temperatures are created and must be maintained continuously.

On the other hand, many conservatives were critics, and deservedly so, of any method which seemed less reliable than established stoker practice insured them—and had to be shown, not by a single unit over a short test period, with equipment handled by detailed experts—but by records of continuous performance on a production basis with equipment sturdy, simple, and reliable enough to compare with modern stoker installations, which operate very successfully with a minimum of skilled attention.

Today these widely variant viewpoints have been reconciled, have been brought together upon the common plane of dollars and costs results, for a given investment. Less discussion will be heard about efficiencies. High efficiences will be accepted as prima-faciae, and more stress will be laid upon the actual investment costs necessary to attain a given end.

A great deal has been written regarding cost of pulverizing coal, all of which is distinctly misleading when applied to boiler plant practice.

The procedure, in many cases, has been to make a detailed cost sheet, covering interest, depreciation, maintenance, power consumption, and labor, and then to add this total cost per ton to the price of coal, as delivered to the plant. The next step was to stretch the probably efficiency of the pulverized coal firing systems to more than make up for the cost of pulverizing coal, so that a favorable showing could be made in comparison with stokers.

This analysis completely overlooked the corresponding items of cost in a stoker installation which, when carefully analyzed, will be found to be about equal to the cost of a simple, well-designed pulverized coal burning plant.

Tests and operating results applying to the two methods of burning coal can, therefore, be compared directly, because, for every charge in connection with a properly designed pulverized coal system there will be an equal charge in a modern stoker plant. Pulverization cost must, of course, be carefully studied and important development work now in progress can be depended upon to reduce these costs considerably, but with the present state of the art it is not necessary to make any addition to the unit price of coal or to make any deduction from the pulverized coal efficiency before direct comparisons can be made with stoker fired plants.

Unfortunately, pulverized fuel had a tremendous handicap to overcome as a result of its various application to open hearth furnaces, where from its very nature it was and is not an ideal fuel. No discussion of the difficulties there encountered is necessary. They are too well known and understood to require mention.

Many points of unnecessary danger were allowed to creep into such installations, as well as into installations requiring numerous subdivisions from a central distributing system—such as small forge furnaces, sheet and pair furnaces, etc. Most of these dangers could have been avoided by careful attention to detail construction and operation, and will be in the future, as reference to the following code recently recommended for adoption by one of the largest industrial companies will indicate that such danger points are now recognized and *must* be guarded against.

Code Recommended for Adoption by Carnegie Steel Company.

1. A cloud of fine coal dust is as dangerous as a

body of unconfined natural gas if the dust is liberated where there is a fire or heat that would ignite gas.

2. Plants for crushing or pulverizing coal must be kept free from accumulations of finely pulverized coal that might be brought into suspension in the air.

3. Removal of accumulations of coal dust should be done by means of an exhaust system that will draw it through hose or piping and discharge it into a container without permitting it to again get into circulation with the air.

4. Buildings must be kept thoroughly ventilated at all seasons of the year when a pulverizing or crushing plant, or any part of one, is in operation.

5. Torches or open lights of any kind must not be used in any part of the plant at any time, whether or not the plant or any part of it is in operation.

6. Smoking within any enclosure where coal is crushed, pulverized or stored, must be entirely prohibited at all times.

7. Cleanliness must be strictly observed, and no accumulations of material of any kind, not necessary for present use in operating, should be permitted within any part of the plant.

8. Heat originating from any source that will raise the temperature of any material above 100 deg. must not be permitted in contact with a coal container.

9. Pulverized coal must not be permitted to remain in a packed or caked condition within piping or containers.

10. Heat of coal within a dryer, and after leaving it, must be perfectly controlled, and coal must not leave the pulverizer when its temperature is above 150 deg. F.

11. If a dryer is to be stopped for any considerable period of time, say five minutes or more, or if a dryer should unavoidably be stopped and it is evident the delay will be five minutes or more, should the dryer in either case contain coal—heat from the furnace must be entirely shut off or diverted so that none can enter the dryer.

12. At any time when combustion is in progress or the temperature of coal within a storage bin is about 180 deg. F., a fresh supply of coal must not be added. Such as is in the bin must first be removed and the bin cooled to normal temperature.

13. When the transfer of coal is to be stopped for any considerable period of time, coal in the transfer line must be entirely blown out.

14. Transfer of coal from pulverizing plant to points of consumption must be so positively regulated as to leave no opportunity for filling bins to overflowing; where a signal system is used, orders must be repeated and recorded. Where messengers are employed to arrange valves or carry information, they must report to the pulverizing plant in person before any coal is started forward.

15. When starting a fire in a drying furnace, paper or other light material that might be drawn by the draft into the dryer, must not be used for lighting.

16. Coal must not be admitted within a combustion chamber unless a flame of such proportions as will insure ignition at every point of entrance has first been placed before the burners.

17. When a pulverizing plant has been stopped for a considerable period of time that might be long enough for spontaneous combustion to begin, great care must be taken to avoid sending hot coal through a transfer line.

18. When coal is distributed by the continuous flow system and used direct from the transfer pipe, great care must be exercised to prevent a drop of pressure in the transfer line below the pressure of secondary air injected at burners. Also where this system of distributing coal is in operation, at no time shall the quantity supplied to the transfer line be less than the maximum amount required for all burners that may be in operation.

19. If the transfer line should become clogged so that coal will not travel, the secondary air must be immediately shut off, and when the clog is removed, careful examination must be made to see that no particles remain in the line that could by any possibility start combustion.

20. Care must be exercised to keep burners open or keep coal from coking in them.

21. Conveyors or elevators should be kept tightly enclosed at all times.

22. Hatch lids of bins must never be opened while coal is entering the bins. They should not be opened unnecessarily, and they should be locked to prevent opening by others than those properly authorized to do so.

23. Motors installed within buildings must be inspected at intervals for deposits of dust within their casing.

During the last few years attention has been concentrated upon steam generation applications of pulverized fuels, and a new set of conditions has been discovered. Boilers are and must be automatically controlled units, which operate at relatively high thermal efficiencies. This is not true of metallurgical furnaces, where product is the major consideration. In boiler operation, furnace upkeep is a relatively small item of operating costs, and any great increase in this item will be quickly marked. This is less true in metallurgical furnaces, where brickwork destruction is a natural result of normal operations.

It took but a short experience firing fuels in suspension to develop the importance and necessity of specially designed and constructed combustion chambers. Much work has been done along this line, various methods of water-cooling and air-porting, various characters of high temperature, erosion-resisting, non-slagging refractories have been and are being developed. Ideal results are still in the future, but now that the condition is clearly recognized, it is merely a question of time before a satisfactory solution will be found.

One of the most interesting problems which pulverized firing seems to solve in a most practical way is that of combination fuels. This has always been an unsatisfactory operation at blast furnaces for instance, and at coke plants. Stokers do not lend themselves to this adaptation—pulverized fuels do.

The blast furnace becomes more and more a power plant with each passing year, as motor drives become practice in steel mills. Blast furnace gas is an ideal source of fuel supply, but blast furnace operation is none too uniform in its delivery of available surplus for power. Some auxiliary fuel must be supplied to maintain the power output constant, at least in average plants as now operated.

Pulverized fuel firing assumes the same characteristics as blast furnace gas, both as to combustion chambers and as to burners and air admissions. Either fuel can be cut off or cut in at a moment's notice. Charts taken from the operation at the most notable installation of this combination show but the slightest evidence of the frequent changes which are taken care of. Since ample combustion chambers are necessary for either fuel, and where provided, very high efficiencies are being obtained at high ratings and with small operating crews.

A number of large installations at blast furnaces are now contemplated and the near future should show a marked development at such points.

One tendency in steam generation, shown particularly by stoker-fired central station units, which has not been followed up by pulverized fuel units, is extremely high over-ratings. Most of the pulverized units are operated at lower ratings than will satisfy the central station operator where 400 per cent no longer creates comment.

There is no reason, however, why the same tonnage of fuel cannot be burned under the same comparative boilers in one form as well as the other, and there is every reason to expect that such will be the case, and at much better efficiencies in suspension at those higher ratings.

The general tendency in pulverized firing is toward simplification of equipment. Definite conclusions have now been drawn that dryers may be eliminated—it being better economy to evaporate the moisture content in 99 per cent efficient boiler-furnace than in a 60 per cent efficient indirect-drier.

Elimination of the drier eliminates a real hazard, besides reducing costs.

Definite conclusions have also been drawn as to the extent to which fine grinding is essential.

What seemed like impossibly coarse coal is now being burned with complete success. This applies to bituminous coals only, however, and not to coke-braizes, or anthracites which must still be finely ground.

Coarser grinding is reflected in lower preparation costs, less power, lower repairs, lower overhead, less investment due to increased production of mills.

In many plants distributing systems have been eliminated and the direct-fired method is installed. The pulverizer is placed immediately at the boiler-furnace with direct fuel pipe supply to the furnace.

Such an installation involves a pulverizer unit as reliable as the boiler itself, more reliable than a stoker, a pulverizer which will handle wet coal, and operate continuously week in and week out on a low power consumption. Several such pulverizers have recently been installed under various types of boilers with capacities ranging from 1,000 hp. to 2,500 hp., depending upon the character of the coal supply.

One feature which this simple method of firing possesses is its susceptibility to automatic control, using existing control equipment in combination with the boiler which it supplies.

Not much attention has been given to this question of automatic regulation of pulverized firing, probably because of the extraordinary results of the excellent combustion obtained, but now that central stations are adopting this method of burning coal, in large, modern, specially designed units, regulation will inevitably assume the importance it deserves. The mere fact that pulverized combustion is so susceptible to careful control, and that very high efficiencies, between 80 and 90 per cent are demanded, will surely bring about this result.

It is far more difficult to control a screw-feed working in finely powdered coal due to its tending to flow, than a screw-feed handling raw coal.

Another feature of the direct method is the reduction in unnecessary spares, which will usually be found present where distributing systems are employed.

Should the average plant executive be asked to O.K. an appropriation request for *double* the stoker equipment necessary to develop a given boiler-horsepower, he would probably hesitate and ask for a revision of the estimate.

Such has been the practice where pulverizers are installed to operate during part time. The bins were filled during the short load periods and the pulverizers, driers, etc., kept idle during heavy load periods. Where the power required for pulverizing equipment is excessive, this practice may be justified—but a better solution will be found in equipment with very low power factor and great reliability.

Whatever develops will be quickly welcomed, for never was the interest in the general subject more sustained and widespread than at the present moment, when industrial recuperation indicates a great revival in power applications and in modernized power production.

CHEMISTRY AND PHYSICS OF GAS WORKS REFRACTORIES

Before the Midland Junior Gas Association, T. F. E. Rhead read a long and highly technical paper, in which the chemical and physical properties of the raw materials and finished products were expounded upon.

Refractory materials might be classed as acids, bases, or neutral bodies, but it was only with the acid refractories, comprising fireclays, siliceous clays and rocks, and silica rock and sand, that the lecturer was momentarily concerned.

Speaking of the properties of fireclays, it was shown that one of the most valuable was the absorption of water to form a plastic mass. The degree of plasticity depends upon the quantity of colloidal matter in the clay, and methods of increasing or decreasing this plasticity are given. A further important property of clay is its binding power. A correct rate of drying clay is very important; too rapid drying results in cracking, although shrinkage may be partly counteracted, by the addition of grog.

Continuing, the author explains the effect of heat upon the various constituents of clay, also on mixtures of clay constituents. A source of trouble in making alumina refractories, is the tendency to contract which alumina possesses. The addition of silica to alumina depresses the melting-point, whilst a jointing mixture of clay and silica will cause trouble. The refractoriness of clay is also reduced by the reaction of Fe_2O_3 (found in clay) and lime, which form easily fusible compounds at 1,200 deg. C.

The addition of grog gives the finished article a more porous texture, enabling rapid change of temperature to be withstood without cracking. The quantity to be added, however, is limited by the fact that the strength of the refractory is reduced.

The author then speaks of the various properties of fireclay and silica bricks. With silica bricks, the larger the proportion of tridymite and cristobalite, the better the brick will prove in use. At high temperatures, porous bricks are better heat conductors than those of dense texture. A strong point in favor of the silica brick, is the fact that it will stand a greater load when hot, than firebrick. The strength at high temperature is controlled by the adjustment of the proportions and sizes of the ingredients.

Follansbee Bros. Co. Operate New Steel Unit

The Modern Steel Plant of the Follansbee Brothers Company at Toronto, Ohio, Now in Operation—Designed Especially for the Production of Open Hearth Steel Sheets.

THE new plant of the Follansbee Brothers Co., manufacturers of sheet steel and tin plate, was recently put into operation and is a fine example of a modern mill designed especially for the production of high grade open hearth steel sheets. This plant supplements the company's older operation at Follansbee, W. Va., where the company commenced the manufacture of sheet steel and tin plate in 1904. The business has grown to such an extent that the Follansbee mill now has an annual production of over 60,000 tons of finished steel, and the Toronto mill was made necessary through increasing business. Its capacity is similar to the Follansbee Mill.

The new plant is located just below Toronto, Ohio, adjacent to the Ohio River and on the main line of the Pittsburgh and Cleveland branch of the Pennsylvania Railroad, where excellent facilities are assured for the transportation of raw materials and finished product. It is probably the first plant of its kind to be electrically driven throughout, power being received from the company's own power station adjoining the plant. An abundant supply of water is available and coal will be supplied from the Company's mine adjoining the property. Provision is also made for the receipt of outside coal when desirable.

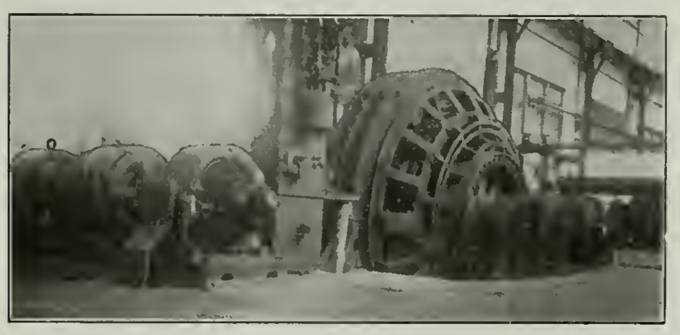


Fig. 1—View of motor, exciter set and main circuit breaker.

The mill site is graded and filled so as to be above the highest water level of the Ohio River. The site is peculiarly well adapted to a mill of this type, as the ground is level and admits of future additions at a minimum expenditure. The property adjoins the electric traction line to Steubenville and East Liverpool. On its forty acres the Company has erected to date ninety-six brick houses for its employes.

The equipment consists of four 40-ton open hearth steel furnaces, four ingot furnaces, one 15-ton steam hydraulic press, one 30 in. reversing bar mill, ten hot mills, four being 50 in., three 44 in. and three 40 in., sheet and pair furnaces, two Dressler Continuous Annealing Kilns. In addition there are the various shears, cranes, and smaller apparatus usually found in a mill of this type. There is also a complete carpenter shop, machine shop and store room. Particular attention has been paid to the handling of material for the various processes and the mill is furnished with a large number of electric cranes, manipulators, etc., to facilitate rapid handling. Special provision was made to obtain maximum storage of both raw and finished material with a minimum requirement of labor in handling it.

Various types of fuel will be used according to the practice which has been developed by the company in the past. The open hearth furnaces will be fired either with oil or producer gas, the gas being supplied by a producer house containing eight Hughes Automatic Gas Producers. Coal from the mine will be conveyed to the power plant by a belt conveyor approximately 1,000 ft. in length, or can be received in hopper bottom cars from the railroad tracks adjoining producer house and power house. The coal is crushed and elevated to an overhead storage bin from which it is fed to the producers. The sheet and pair furnaces are fired with powdered coal prepared in the powdered coal plant housed in a separate building. A Flinn & Dreffein Gas Washing Plant with a capacity for thoroughly cleaning the gas from any two producers adjoins the producer house. This will furnish gas for the annealing ovens, drying ovens and other special purposes.

The electrical features of the mill conform to standard practice but also contain some special features of interest. Each group of sheet mills is driven by a 1,500 hp Allis-Chalmers Induction Motor through a Falk Herring Bone Gear set with suitable fly wheels for smoothing out the peaks, a liquid slip regulator being part of each set. The bar mill is electrically driven by a 5,000 hp maximum rated Westinghouse Reversing Mill Motor with a speed in either direction of 0 to 100 rpm. The mill motor is of the general reversing type, operating on 600 volt direct current and receiving its current supply from a fly wheel motor generator set. The motor, exciter set and main circuit breaker are shown in Figure (1). The bar mill is of the same design as that in operation at the Follansbee plant but electric drive was decided upon in place of the steam engine drive at Follansbee. The reversing motor is installed in a separate room with a removable door between the motor and bar mill. Located in the same room is the exciter set, motor-generator fly wheel set, slip regulator and control apparatus, two General Electric Motor-Generator Sets for supplying 250 volt direct current to the cranes, manipulators, etc., and the necessary 2,300/200 volt transformers for mill lighting, etc., are also installed in this room. It is served by a crane to facilitate handling of repairs. The power cables are carried from the power house to the mill over a structural steel bridge. This bridge also carries a high pressure steam line supplying the forge press, gas producers, mill heating and heating of the company houses some distance from the mill.

Power Plant.

Of particular interest is the new power station built especially for this mill. It was aimed to obtain a maximum of simplicity consistent with good economy, this being especially desirable in a power plant serving a steel mill. Continuity of service is the one essential characteristic and only a short delay in the mill operation will soon offset small economies obtainable in the public service plant through extreme refinement in design. A view through the boiler room is shown in Figure two (2).

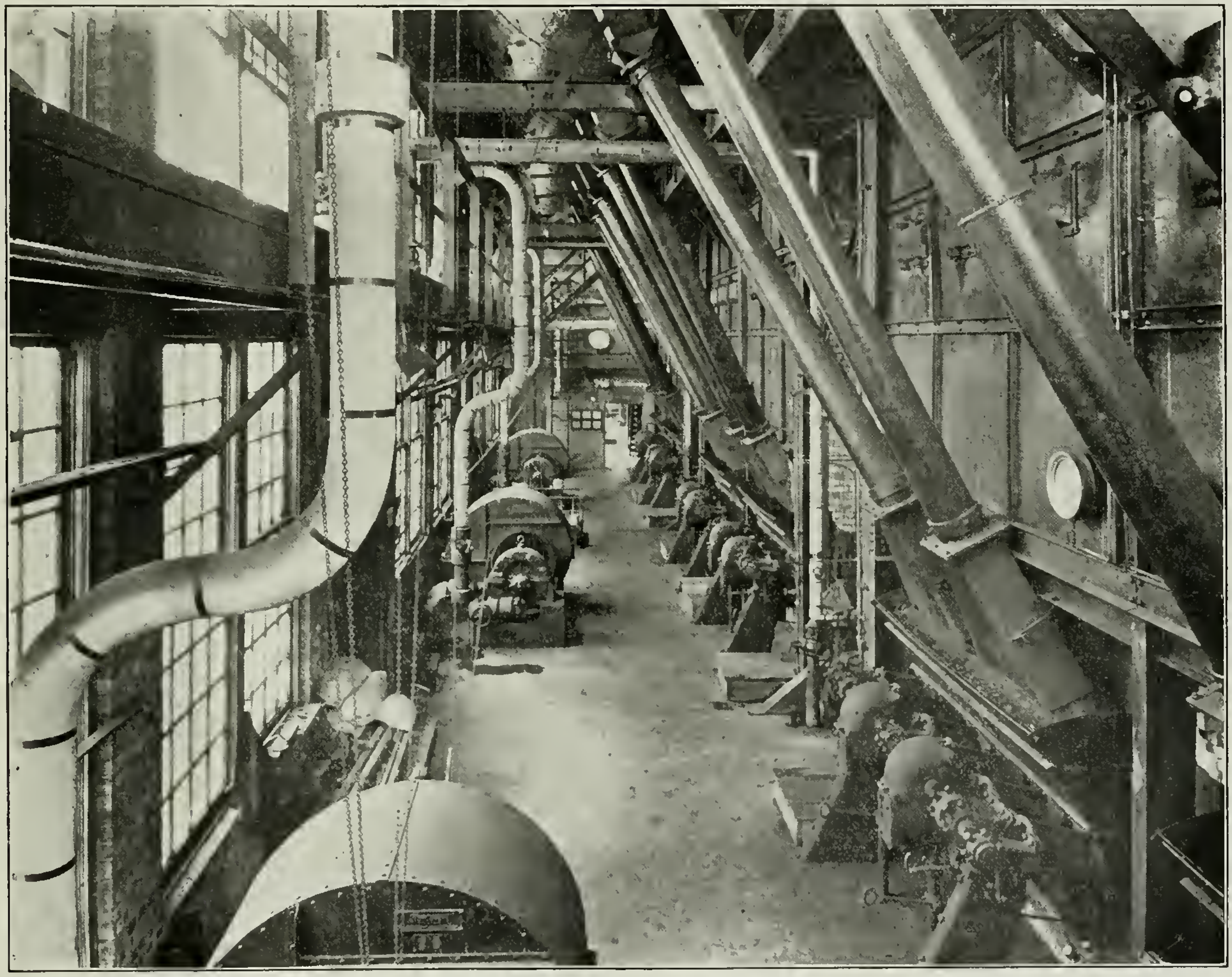


Fig. 2—View through boiler room.

The Boiler Room contains six 600 hp Badenhausen Water Tube Boilers with superheaters designed for operation at 200 lb. steam pressure and 100 deg. superheat. Each boiler has 6,000 sq. ft. of heating surface, is served by a six retort Westinghouse Under-feed Stoker, and is provided with mechanical soot blowers, feed water regulator, steam flow meter, and Precision Draft Gauge. Under normal conditions they will operate at approximately 175 per cent of rating. The boilers are set two in a battery forming three batteries, each of which is connected to an independent brick stack 8 ft. dia. x 175 ft. in height, allowing for a short and inexpensive steel plate breeching directly into the stack.

Three turbine driven draft fans, one for each battery, are located in front of the boilers on the boiler room floor and furnish air for the stokers. Each fan has a maximum capacity of 44,000 cu. ft. of air per minute against a static pressure of 7 inches water gauge at a speed of 1,600 rpm, which is sufficient for two boilers at 250 per cent rating. Each fan discharges into a common concrete air duct running the full length of the boiler house. The air duct has sectionalizing gates so that any battery of boilers with its corresponding fan may be operated as a separate unit or a fan may be shut off entirely through a gate in the fan outlet and the boilers supplied with air from the main air duct. In this way any boiler may be served by whatever fans are in operation. Each pair of stokers is driven by a separate engine and so arranged that any engine may drive any stoker. If desirable two boilers, one stack, one fan and the stoker engine becomes a single operating unit. The location of the draft fans on the boiler room floor insures the proper oversight for continuous operation. The turbines are likely to receive greater attention than when located in the basement. The boilers are set with the lower drum 7 ft. above the boiler room floor resulting in a large furnace which is desirable for carrying high ratings and efficient operation. The boiler settings are arranged so that there is an observation door in the bridgewall and the floor is dropped down behind the boilers so that these doors are accessible to the firemen.

Coal and Ash Handling.

The chief source of coal will be the Company's mining operation adjacent to the mill. It will be crushed and weighed at the tipple and transported to the power house on an elevated belt conveyor and discharged to the storage bins. The power house coal bunker runs the full length of the boiler room. It is a steel bin with a capacity of about three hundred tons, or sufficient for 36-hour runs of the power house. Coal is distributed to the stoker hoppers through individual gates and chutes, two for each boiler.

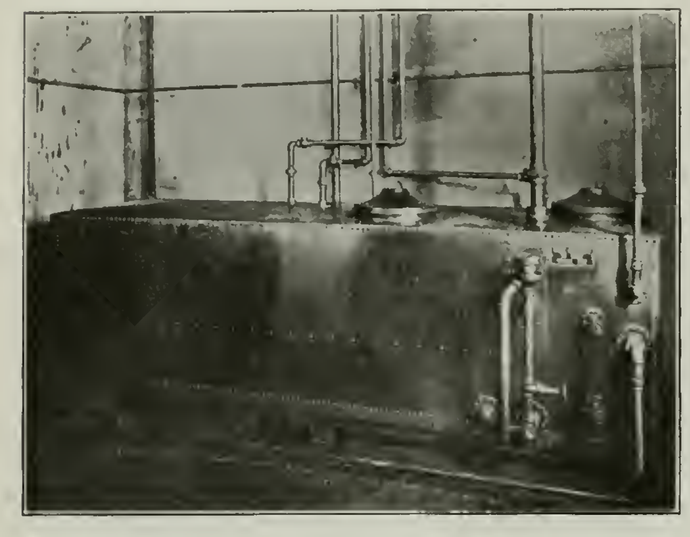


Fig. 3.

Each boiler foundation includes a large ash hopper with sufficient storage for an eight hour run. Each hopper is furnished with a heavy cast iron rack and pinion gate with two openings, each 30 in. x 36 in. From the hopper ash is dumped into side dump steel cars running on a track in a tunnel under the boilers. At one end they are dumped into an automatic skip hoist which discharges the ash into a brick ash bunker outside the power house. Ashes may be removed from the bunker either by railroad car or by truck. A large amount of filling is required in the neighborhood of the plant and trucks will be used for some time. The ash tunnel has a clear height of over 6 ft. and is well ventilated to permit of comfort for the ash handling men. A dust chute from the back of each boiler discharges into a similar car underneath the boiler room and this car is dumped into the same skip hoist and carried up to the ash bunker.

Turbine Room.

Electricity is generated at 2,300 volt, 60 cycle, 3 phase by three high pressure condensing steam turbine units, two of 3,000 kw rating at 80 per cent power factor and one at 1,500 kw at 80 per cent power factor. The turbines are designed with a special overload nozzle so that a correspondingly greater load can be carried at any power factor over 80 per cent. It is expected that the average load will be between 4,000 kw and 5,000 kw and will be taken care of by the two larger units, the small one being held in reserve for days when the mill is not in full operation. Should one of the turbine units be shut down for repairs it will be possible to carry the mill load with the remaining two units. Excitation is furnished by two separate exciter units, one of which is motor driven and the other driven by a non-condensing steam turbine. Ventilating ducts from the outside carry air to the turbo generators.

The oiling system for the turbine units is worthy of note and was furnished by the S. F. Bowser Co. Inc. The oil from the units is discharged into a large receiving tank in the basement and from there pumped to a filter tank equipped with duplicate pumping units located on a mezzanine floor in the turbine room. It is then filtered and distributed to an overhead storage tank from which it flows by gravity to the turbines. The receiving tank is large enough to accommodate the entire oil supply of the largest turbine units so that if it is desirable to empty the oiling system of one of the large turbines it can be done without waste or inconvenience. Figure three (3) shows the Filter and Figure four (4) the receiving tank with automatic water separator in the basement.

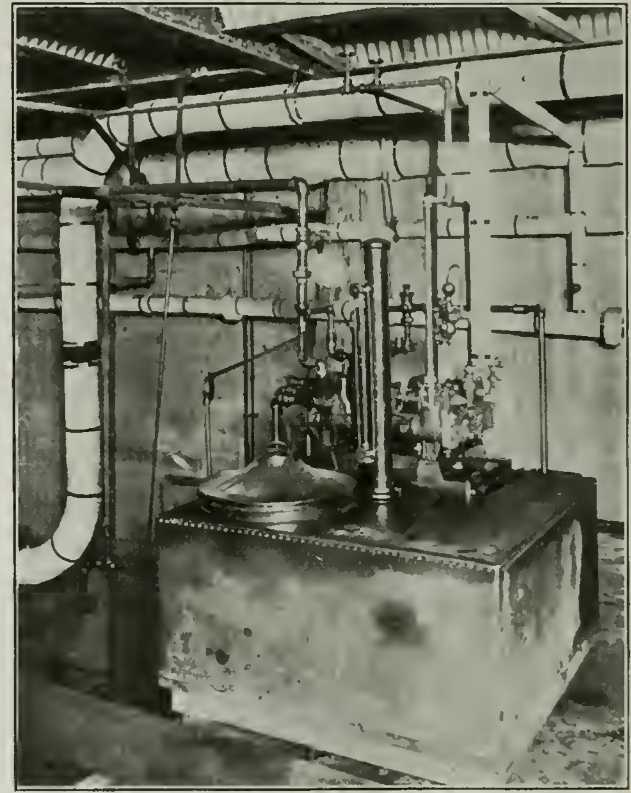


Fig. 4.

The main units are served by surface condensers located directly underneath the turbines. Circulating water is furnished by motor driven centrifugal pumps in a house built in the river, each condenser having its own circulating pump and water lines. The piping in the pump house, however, is so arranged that any condenser may be taken care of by either pump. In the suction line of each pump is an Elliot Twin Strainer and the inlet to the pumps is in a forebay of the pump house which is furnished with removable trash racks. The pumps may be operated by automatic starters from push button stations in the power house or by an operator at the pump house. The air pumps are of the steam ejector type with an auxiliary condenser for reclaiming the steam used in the ejectors. Steam driven condensate pumps handle the condensate to the heater. For non-condensing operation the main turbines may discharge directly to atmosphere through individual atmospheric relief valves and exhaust lines.

Boiler feed water is obtained principally from the turbine condensate and heated in a 4,000 hp Webster Open Feed Water Heater. The heater is installed on a mezzanine floor in one corner of the turbine room with the turbine driven boiler feed pumps directly underneath. The heater is furnished with an indicating V notch meter for recording the flow to the boilers. Exhaust steam from all the auxiliaries is carried into the main exhaust line under the floor and up to the heater. Heat balance will be taken care of by operating the required number of steam driven auxiliaries. Ohio River water is used for makeup, provision being made for proper treatment of the make-up supply.

Particular pains were taken with the piping of the station. All high pressure steam piping is extra heavy with steel valves, monel metal fitted. Long radius bends have been used extensively and wherever feasible welded joints have been used in place of fittings. All valves throughout the entire plant are accessible through suitable galleries. The piping in the power house was furnished and installed by The National Valve and Mfg. Co. of Pittsburgh.

It is expected that the over-all economy of the power plant and electrically driven mill will be such as to show the decided advantages of a central station and electric drive, both from the standpoint of economy and ease of operation. The fuel consumption per ton of finished product should be considerably less than in a combination steam and electrically driven mill.

The design and construction of the new plant was under the supervision of Joseph Breslove, Consulting Engineer, Oliver Building, Pittsburgh, and C. W. Kinter, Chief Engineer of the Follansbee Bros. Co. The special features are based on long experience in manufacturing high grade qualities of sheet steel.

The Alabama Company's No. 1 Stack Breaks Production Record on Low Fuel Consumption

Production Increased 17 Per Cent, Coke Consumption Decreased 30 Per Cent—Labor Force Reduced 50 Per Cent.

By H. R. STUYVESANT
General Superintendent Blast Furnaces

THE improvements on No. 1 Gadsden stack together with the expected benefits derived from said improvements, was fully described in the May, 1921, issue of The Blast Furnace & Steel Plant.

No. 1 Stack was blown in October 10th, 1921. The increased production, and decreased fuel consumption is far above expectations. Actual operating data for the month of March is shown in table No. 1. During the first half of March the average daily production was 261 tons of foundry iron on 2,795 pounds of coke per ton of iron, while the average for the month shows 245 tons of iron on 2,820 pounds of coke per ton of metal.

Taking into consideration working volume, slag volume, yield quality of coke, working on special grades, no scrap used, and no off iron produced, this is considered remarkable performance and is due to the fact that the furnace lines and distribution was corrected, together with successful practice. The success of the operating is due to the fact that the operator strives for uniform operation, giving the highest production combined with the lowest fuel consumption, obtaining the highest quality product with the greatest possible economy. The evidence of highest quality product is based on the fact that during the present campaign covering a period of six months including the blow in, the furnace has produced but two casts of iron running over .049 per cent sulphur which is only .002 per cent of the total six months production.

Table No. 2 shows actual monthly operating data including blowing in period. In referring to table No. 2 it might be well to keep in mind the following facts: First, the coke used from October the 10th to February the 20th was dirty unscreened coke. Chemically varying in ash content from 12.50 to 15.89 per cent and physically varying from 58 to 70 in friability, or hardness. Second, the wide range of silicons required for the special grades. Third, to the frequent complete burden changes required for the different brands of iron produced.

The Southern Pig Iron and Coke Association concludes that a furnace should burn sixty pounds of coke per twenty-four hours for each cubic foot of working volume, assuming a base coke with the following chemical specifications, fixed carbon 89.00 per cent, ash 9 to 10 per cent, volatile matter 1 to 2 per cent, and sulphur 1.00 per cent and under. Regarding the physical structure of this base coke, the adapted standard reads as follows: It should be tough, but not dense or friable, and free from braize.

Table No. 3 shows No. 1 Gadsden stack on a comparative basis while (A) of this table shows theoretical data according to the established associations ratings, using the base coke and base theoretical yield on a furnace the size of No. 1 Gadsden stack which has a working volume of 10,838 cubic feet. (B) of table No. 3 shows actual operating data on No. 1 stack for the month of March. It might be well to mention the fact that the physical structure of the coke used during the month of March was not up to the standard adopted by the association. (C) of table No. 3 shows theoretical data on No. 1 furnace assuming the coke used to be the same as that shown for plant No. 3, table No. 4. While (D) of table No. 3 shows theoretical data on No. 1 furnace assuming same coke as that of plant No. 3, table No. 4, together with the base theoretical yield of 51.50 per cent. In looking over table No. 3 keep in mind that (C) and (D) of table No. 3 were calculated, assuming as a base the actual practice on No. 1 furnace for the month of March, and during this month the coke used was not up to the physical standard adopted by the association, whereas if it were the actual practice, (B) table No. 3, as well as comparative data (C) and (D) would correspondingly show increased production and lower coke consumption.

While the majority of the Southern plants have low grade ores and high slag volumes to contend with, in referring to table No. 4 you will note the majority of the plants are favored with good coke both chemically and physically. Table No. 4 shows a comparative report on chemical and physical analysis of blast furnace cokes used at the different operations in the Birmingham district. The names of the different plants are not given, but are designated Nos. 1 to 5.

Foundry cokes of good physical and chemical qualities are also produced in the Birmingham district,

TABLE NO. 1

The Alabama Company's No. 1 Furnace—Average Blast Furnace Practice Month of March, 1922
Working Volume 10,838 Cubic Feet

Working on special grades ranging from 1.50 to 4.00 Silicon

Date, March	Average Daily Production, G.T.	Pounds per ton of pig		Analysis of Iron		Ave. Coke Ash	Ave. Ore and Scrap Yield	Cubic ft. Air per Pound of Coke	Pounds of Coke burned per cubic ft. working Volume	Tons Iron produced per 100 cu. ft. working Volume
		Coke	Slag Volume Ave. Month	Sil.	Sul.					
1	279	2707	2200	2.05	.018	13.83	37.10	54	66	2.58
2	252	2997	...	2.26	.022	...	...	..	..	2.34
3	254	2973	...	2.77	.023	...	...	..	..	2.35
4	263	2961	...	2.72	.018	...	...	..	..	2.43
5	258	2973	...	2.60	.024	...	...	..	..	2.38
6	277	2641	...	2.07	.022	...	...	..	..	2.57
7	239	2962	...	2.30	.020	...	...	..	..	2.21
8	264	2458	...	2.28	.025	...	...	..	..	2.43
9	276	2693	...	2.26	.026	...	...	..	..	2.56
10	279	2516	...	2.04	.025	...	...	..	..	2.58
11	267	2673	...	2.10	.021	...	...	..	..	2.47
12	264	2637	...	2.31	.021	...	...	..	..	2.43
13	240	2853	...	2.08	.022	...	...	..	..	2.22
14	252	2889	...	1.88	.028	...	...	..	..	2.34
15	252	3002	...	2.56	.024	...	...	..	..	2.34
Ave. 15 days	261	2795	2200	2.28	.023	13.83	37.10	54	66	2.41
Ave. month	256	2820	2200	2.35	.023	13.83	37.10	54	66	2.35

TABLE NO. 2

The Alabama Company's No. 1 Furnace—Monthly Practice
Working on Special Grades

Ranging from 1.25 to 4.00 Silicon

Month October 10th to 31st Including blow in	Year	Average Production Gross tons	Average analysis of iron		Average Ore and Scrap Yield	Average Coke Ash	Pounds per ton		Number of days on different brands of iron requiring complete Burden Chance
			Sil.	Sul.			Coke	Slag Volume Ave.	
Oct. 10th to 31st	1921	173	2.45	.027	37.40	13.75	3438	...	Etowah, 21 days
November	1921	235	2.42	.023	37.12	14.36	2957	...	Etowah, 25 days Clifton, 5 days
December	1921	246	2.65	.026	37.35	14.22	3081	... 2500	Etowah, 26 days Clifton, 5 days
January	1922	252	2.38	.027	37.18	13.79	3026	...	Etowah, 25 days Clifton, 2 days High Phos., 4 days
February	1922	244	2.02	.024	38.02	15.15	2939	...	Etowah, 20 days Clifton, 8 days
March	1922	255	2.35	.023	37.10	13.67	2820	...	Etowah, 31 days
Average Nov. 1st, to April 1st,	1921 1922	247	2.36	.024	37.35	14.14	2976	2500	

TABLE NO. 3

The Alabama Company's No. 1 Furnace On Approximate Comparative Basis

Southern Ohio Pig Iron and Coke Association Rating	Cubic feet working Volume	Pounds of coke burned per cubic ft. working Volume	Pounds of coke burned per 24 hours	Foundry. Pounds of coke per gross ton of iron produced	Basic. Pounds of coke per gross ton of iron produced	Gross tons of Fdry. per 24 hours	Gross tons of Basic per 24 hours
(A) Coke Fixed Carbon 89.00 Ash 9.50 Theoretical Yield 51.50 Pounds of coke per ton of pig Foundry 2300 Basic 2000	10,838	60	650,280	2300	2000	282	325
(B) Actual Alabama Company No. 1, Month of March Coke Fixed Carbon 84.92 Ash 13.83 Ore and Scrap Yield 37.10	10,838	66	719,100	2820	2494	255	288
(C) Comparison Alabama Company, No. 1 with Coke 90.70 Fixed Carbon, Ash, 7.90 same as plant No. 3, Table No. 4, with 37.10 Ore and Scrap Yield.	10,838	61.67	668,418	2532	2206	264	303
(D) Comparison Alabama Company, No. 1 with coke 90.70 Fixed Carbon, Ash 7.90 Theoretical Yield 51.50.	10,838	61.67	668,418	2287	1961	292	340

TABLE NO. 4

Comparative Chemical and Physical Analysis of Blast Furnace Cokes Birmingham District

Name of Oven	The Alabama Co. Semet Solvay	Plant No. 1 Koppers	Plant No. 2 Koppers	Plant No. 3 Koppers	Plant No. 4 Semet Solvay	Plant No. 5 Koppers
Time carbonized, hours	18	20	17	19	34	20
Physical properties—						
Shatter	69	70	70	70	72	70
Friability	68	69	69	72	73	71
True density	1.96	...	1.75	2.04	1.98	...
Apparent density	1.08	...	1.02	1.14	1.09	...
Porosity	45	...	42	44	45	...
Chemical analysis—						
Moisture	.18	.50	1.53	.25	.80	.50
Volatile matter	1.07	2.68	2.17	1.15	1.55	1.04
Fixed carbon	84.92	87.74	84.75	90.70	85.42	89.38
Ash	13.83	9.08	10.55	7.90	12.23	9.08
Sulphur	.80	1.10	.74	1.11	.68	1.10
Btu	12,280	12,929	12,718	13,044	12,388	...
Approximate available carbon	76.92	82.08	78.57	85.65	78.25	83.70

TABLE NO. 5

Comparative Report on Present and Past Furnace Dimensions and Practice

	Hearth diameter ft.	Bosh diameter ft.	Bosh angle deg.	Height of furnace	Stock Line diam. ft.	Daily average production	Kind of iron produced	Average pounds of coke per ton iron	Ave. coke ash	Physical condition of coke	Ore and scrap yield	Cubic ft. wind per minute
Average years 1918 and 1919	11′	17′ 6″	74	79′	12′ 6″	210	Foundry	4265	15.45	Clean double forked	37.30	36,000
Average Nov. 1st, 1921 to April 1st, 1922	12′ 3″	17′ 8″	78	79′	12′	247	Foundry	2976	14.14	Dirty Unscreened	37.35	28,000

the following shows the physical and chemical analysis of two of the best foundry cokes in the South.

Name	Brookwood	Searles
Oven	Beehive	Beehive
Time carbonized	72 hours	72 hours
Coal seam	Milldale	Searles
Physical properties—		
Shatter	76	72
Friability	73	67
True density	2.26	1.91
Apparent density	1.07	.95
Porosity	53	50
Chemical analysis—		
Moisture	.20	.50
Volatile matter	.90	1.35
Fixed carbon	88.57	86.62
Ash	10.33	11.53
Sulphur	.85	.87
Btu	12,624	12,473

The present and past dimensions, etc., of No. 1 stack as well as the average practice is shown in table No. 5. While the average daily production was increased 37 tons, the average coke consumption was decreased 1,289 pounds per ton of iron produced, or a saving of 159 tons of coke per day. Assuming the price of coke F.O.B. furnace to be $5.00 per ton, the saving of coke alone for a year amounts to $290,175.00. On the other hand manufacturing costs was materially reduced, owing to the fact that the labor force required to operate was reduced approximately fifty per cent, while the production was increased 37 tons per day.

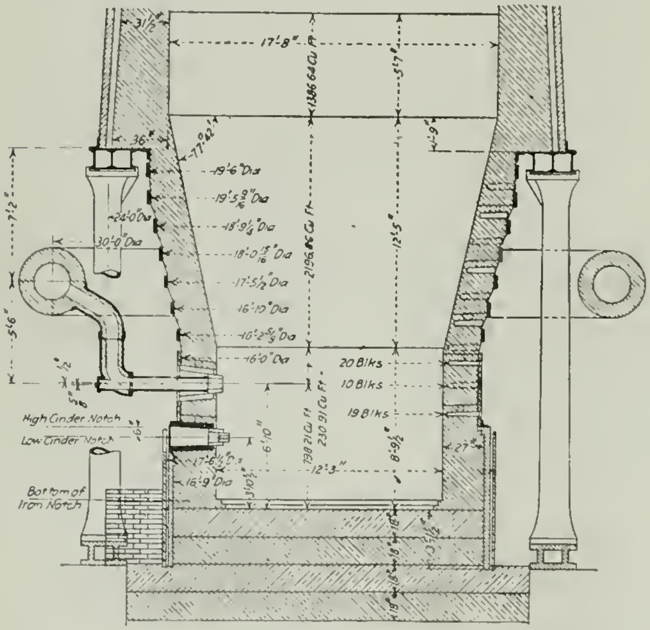


Fig. 1—Section through No. 1 Furnace.

With the idea in mind that uniformity and heat concentration is the secret of economical blast furnace practice, the company has now under plans to improve raw materials both chemically and physically in order to attain uniformity. With improved uniform raw materials production will be increased together with a decrease in fuel consumption thus lowering production costs.

CORROSION OF STEEL INVESTIGATED

A test of the resistance of chromium steels to acid corrosion recently completed by the bureau of standards, Washington, gives the information that the relative resistance of steel to the acid test is not necessarily a criterion of its behavior in other types of corrosion. Pure iron and steels of low chromium content were found to be much more resistant to attack by hydrochloric acid than those containing considerable chromium. However, when corrosion is caused by water and air, the general order of resistance was reversed. This led to the conclusion that the addition of chromium increases the rate of attack by hydrochloric and probably by other acids although this may depend somewhat upon the heat treatment which the steel has received.

Specimens hardened by heat treatment were found to be considerably more resistant to acid attack than samples of the same composition in the annealed state. The addition of nickel is more effective in reducing the intensity of attack by acid than is chromium, since steels containing a considerable amount of this metal were found to be the most resistant to acid of any tested. Specimens with a polished surface almost invariably showed a smaller loss in acid than those which were roughly ground. This difference may be only apparent,however, due to the fact that while the two specimens may have equal surfaces, the one with the ground finish has a slightly greater area exposed on account of minute grooves and ridges.

For resisting corrosion by water and air a considerable amount of chromium in steel is necessary and alloys of this general type were found to be more resistant than were those of low chromium content. However, these latter steels were more resistant than the simple carbon steel or pure iron. Hardening chromium steel by heat treatment retarded corrosion by water and air as it did in the acid test, this being true particularly for the steels of high chromium content, although variations in heat treatment produced little difference in resistance to corrosion in specimens lower in chromium. Adhering patches of oxide scale upon the surface produced a noticeable effect in accelerating the rate of attack in chromium steels.

The alloy containing a high percentage of nickel as well as chromium and found to be attacked the least by acid, also proved more resistant to atmospheric corrosion than most of the chromium steels tested although it was far surpassed by certain of the high chromium materials. In most cases,, corrosion of the chromium steels consisted in an attack at small isolated spots rather than in a general tarnishing and coating of the surface. In view of the fact that adhering particles of scale accelerate the corrosive attack of a steel to a marked degree, this suggests that the presence of inclusions or other defects within the material may be responsible largely for the character of the resulting surface pattern.

Character of service should govern the type of noncorrodible steel to be used. For example, if resistance to severe acid attack is the principal requirement, a high chromium steel is the least suitable of all the materials tested. Most classes of service, however, require fairly satisfactory performance under a variety of conditions. For example, cutlery steel must withstand both acid and atmospheric corrosion as well as possess certain necessary mechanical properties. No single type of noncorrodible steel appears to be suitable for each and every purpose which may arise.

Fuel Economy of Steel Plants

Stenographic Notes of Paper Read Before the Blast Furnace Section of "Verein Deutscher Eisenhuttenleute," April 27, 1921, Published in Stahl und Eisen, December 22, 1921.

By **DR. K. RUMMEL** in Dusseldorf

Translated by Alfred Steinbart of the National Tube Company, Pittsburgh, Pa.

I AM very glad to have, at last, the opportunity to talk before the men who have charge of the operation of the blast furnaces. It would be a greater pleasure if I could convince these men of their own importance in connection with the whole plant, especially with the fuel consumption of the whole plant. The blast furnace has often been called the heart of the plant and not improperly, because it is a fact that the blast furnace propels the streams of material and power through the arteries of the plant giving vigor to the whole. It would be drawing the comparison too far, however, if we would say that the blast furnace man was the soul of the whole plant operation. This the blast furnace man generally is not, because he looks out first for himself and for his own department and you can hardly blame him for this. The blast furnace is a very touchy fellow—we all know that—who has to be treated with the greatest consideration and cannot be experimented with too much. It is, therefore, necessary to step easy in starting with changes at the blast furnace in order to improve the fuel economy of the plant as a whole, including steel works, rolling mills, etc.

The blast furnace gas—though it is the main source of power for our works—is and will always remain a by-product for the blast furnace man. The relative importance between the main product, the iron, and the by-product, the gas, may change somewhat, but it will never change so materially as it has changed in the coke plants where the former by-products really became the most important products and where the coke often is principally made on account of the by-products. But the blast furnace man likes to receive as much credit as possible for the gas supplied to other departments and it is generally the case that such credit is given. In connection with this subject, I would like to mention casually, that the government "Fuel Saving Commission" at Dusseldorf is of the opinion that the valuation placed by the works on the blast furnace gas is much too low and that more credit should be allowed to the blast furnace man for the gas supplied to other departments. (Applause.)

The gas should be paid for better, because it is worth more! Mostly it is paid for according to its heat value. For 1,000 Btu of gas one pays as much as one would pay for 1,000 Btu in coal. That is not right, because 1,000 Btu in gas are worth much more—except when used under boilers where the use of gas is more and more abandoned. Investigation shows that for use in gas engines and the different types of furnaces the gas is worth 25 per cent or 30 per cent more. Such a value might be an inducement to furnish gas to other departments.

Low cost per ton of pig iron should not be paramount. On the contrary, the blast furnace man should feel as a member of the whole works community and he should fill his place in such a manner that the works as a whole is benefitted. There are yet today blast furnace men (those present, of course, excepted) who take a different stand. If the feeling takes root in you that you are principally a member of the whole works community, you will find it possible to improve a little here and there in order to help the fuel economy of the works as a whole.

If, with three blast furnaces working, the pressure of the gas varies from 9 in. of water down to 1¼ in., then it is time that something should be done. To our surprise, we have not found one single plant where an attempt was made, except by request, to determine the amount of gas actually produced by the blast furnace. You will probably be astonished by this statement because you all have gas meters. We have recently made the first attempt of this nature. The results are astonishing. Further investigations are still being carried on and I, therefore, cannot yet report.

We all know that the blast furnace cannot be made to furnish the gas in absolutely uniform volume. There are periods in which the volume of the gas changes, caused by changes and disturbances in the working of the furnace. Such changes cannot be avoided and the plant as a whole has to be prepared for them. But there are also several occasions where good management, anxious to keep up the supply of gas to other departments, can do much to keep the gas volume more constant. This, for instance, is the case during casting. The practice at most plants is to keep the blast on the furnace during this time. But the blast pressure varies at different works and it would be important to investigate how much pressure it is possible to carry at this time in order to avoid lack of gas during casting. In such cases where it is impossible to keep up the pressure, it may be advisable to increase the blast a little at the other furnaces so as to increase the gas production to cover the loss due to casting at one furnace. Several works have informed us that they do blow somewhat stronger at the other furnaces during the time when one furnace casts. This information is very important, because it shows—see also remarks in this connection later on—that the furnaces can stand more blast for short periods without interferring in any way with good operation.

We also believe that the stoves can be operated in such a manner that the surplus gas going to other departments remains uniform in volume, i. e.; the consumption of gas in the blast furnace department proper may be regulated to be more uniform. The replies from the different plants to our questions, however, vary very much, strange to say. At some of the works the changing of stoves causes a very marked dip in the record of gas consumption for the stoves. The reason for this is that quite some time elapses from the point where the gas is taken off at one stove and turned on at the other stove. During this time no gas is used at one stove and the record shows a marked dip. At other words, however, this is not the case. We are now investigating this, but I recommended to you to look into this yourself in order to find the reason. One plant informs us that they are now endeavoring to shorten the time of changing stoves as much as possible. May be that it will be advisable to institute a sort of Taylor System in order to establish a manipulation of valves to shorten the time when the gas is off on a stove. Such attempts can but help to improve uniformity of gas supply over the plant as a whole. It may also be advisable to investigate if not a number of stoves in the plant are changed at the same time, so that a number of stoves are not consuming gas at one time. Further, we have found from the record of gas consumption by the blast furnace department proper, that individual stoves receive different amounts of gas for no reason whatever except that the stove man opens the gas valve more or less out of negligence.

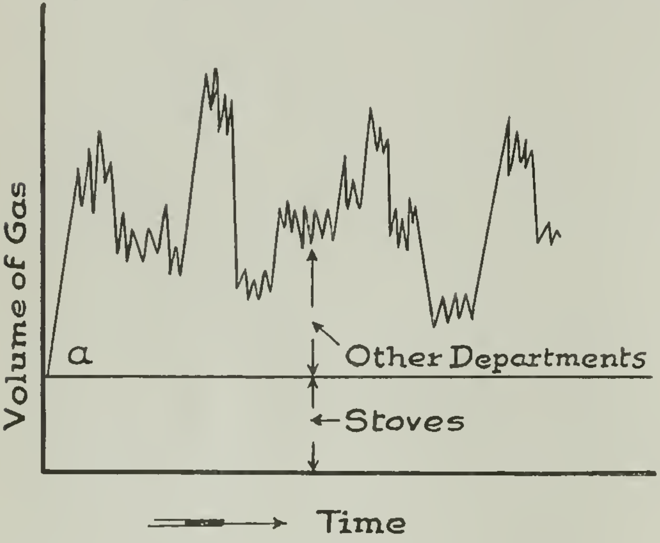


Fig. 1.

These appear to be small matters but they are very important when they result in gas variations of 35,000 cu. ft. per hour. It is, however, not only important that the gas is delivered uniformly to other departments but also that the blast furnace department absorb the irregularities of consumption of other departments. Most of you are probably very enthusiastic about the pressure regulators which are just now being installed at your gas mains to the stoves. I consider the installation of such regulators and the results at which you aim as entirely wrong.

See Figure 1. If you regulate the gas pressure and make it uniform so as to get good combustion and small gas consumption at your stoves, you make your gas consumption uniform. You cut off your gas consumption for stoves with a straight line (see a) at the bottom of the diagram. In doing this you do not in any way lessen the peaks but you simply eliminate them in your own department and throw them into the other departments. And not this alone; you make them far worse in the other departments. This, of course, is very convenient for the blast furnace man but not for the other gentlemen who have to take care of these peaks. I would like to state here, however, that it would be quite wrong to proceed now and install these pressure regulators also in the other departments, because in this way the peaks would be left over and would have to be disposed of by bleeding. But I wish not to be understood that I condemn the gas pressure regulators altogether; on the contrary, they are very useful apparatus if they are used in their proper place. It appears to me, as the proper arrangement, that the blast furnace department try to work up the peaks in the diagram and that they endeavor to give the other departments the regular pressure because nowhere in the works have we such a storage for heat as is offered by the stoves. The stoves should be used as much as possible to store the peaks of gas because of their enormous storage capacity. The time is too short to go into this matter any further, but I will say this; that in order to use up the peaks in the stoves you must install an automatic regulation of the air at the stoves in order to adapt the air pressure to the gas pressure and so get good combustion with variable gas pressure. This can be done by using the above mentioned gas pressure regulator for regulating the air. Then you utilize the same apparatus to throw the peaks into the stoves.

In the last two years a good deal has been already accomplished on the lines pointed out above. There are already works who push their stoves harder at such times where gas is plentiful. There is one works where they work eight (8) hours in the rolling mills and shut down for four (4) hours; work eight hours again and shut down for four hours. During these four hours of shut-down the mill uses very little blast furnace gas. This time is employed to heat up the stoves. This shows that it is quite possible to follow the lines which I have pointed out above in quite some detail. Further, it is the practice to heat the stoves to a very high temperature on Sundays to store as much heat as possible. It is also the practice at some works where they use the "two stove method" to heat up the superfluous stoves on Sundays or at such times during the week when there is a surplus of gas, so that these energies can be utilized at time of demand. It is, therefore, very feasible to utilize the stoves for heat storage.

If you desire to furnish more gas to other departments you must also try to save as much gas as possible in your own department. This, I believe, is done now everywhere, and we have found, to our great satisfaction, that the gas consumption of the stoves has considerably decreased. While in the beginning, when we came around and took snap samples of your stove stack gases, we found often a large amount of air surplus or even carbon monoxide, we have not found this lately because this condition has almost ceased to exist on account of the practice of regularly making such tests and it is a fact that the consumption of gas in the stoves is much lower now.

Not only should gas be saved but also the blast conditions should be improved and savings made. Three methods can be used here:

First: Heat losses of the hot blast can be reduced. I would very much recommend to you to test the temperature drop from stoves to tuyers all along the line, because I am convinced that you will find places along this line where the drop is surprisingly large. We had similar experience in connection with tests on heating furnaces at rolling mills. If you improve the heat losses at these points by better insulation or otherwise, you cannot avoid making a saving. In some cases a thin cover of insulating material will help very much.

Second: And this is still more important—pressure losses of the blast should be avoided. Unnecessary pressure loss means loss of power. At most works, especially at the old one, the blast main show bends which are too short. I would recommend to measure the pressure loss at such bends and to eventually eliminate them if the pressure loss is too great. In connection with pressure losses, allow me to draw your attention to the by-pass line. Dr. Bansen, according to my knowledge, has been the first to point out the serious pressure loss sometimes caused by the same. This line is used to lower the temperature of the blast for regulating purposes and, as it winds through tight places around the stoves it is often made too small. In order to force sufficient cold air through this line it is often the practice to throttle a valve in the main line leading through the stove. This means a loss of energy which sometimes is quite large. I am satisfied that you will try to remedy this. But the fact that the throttling is being practised, and because less blast will enter the furnace at such time is a proof to me that it is possible to blow a furnace some times somewhat lighter without harm and that it is, therefore, feasible to vary the blast somewhat without interferring with good blast furnace operation. We have also learned, during the time of political strife, that it is much less harmful, than most of us thought, to reduce the blast. There are quite a number of plants where they reduce the blast on Sundays, because the blast furnace gas is so valuable for them. All this shows that the furnace will stand it all right to be used as an organ for regulation for the whole gas distributing system. In limits of from 5 per cent to 10 per cent at least, it can in some cases be utilized for the regulation of gas volume.

We have conducted, during the last weeks, tests with gas producers which have proven to us that they can be operated for a very variable production. The tests were made on slagging producers which were operated according to a predetermined schedule as far as gas production was concerned by changing the amount of blast to obtain the desired gas volumes. With the blast furnace, of course, nobody would go that far; but in certain limits regulation is feasible.

Third: The most serious loss, which often occurs through negligence, is the loss of blast through leaks. I do not exaggerate when I claim that some times from 30 per cent to 40 per cent of the blast is lost between blowing engines and tuyeres. To overcome this, I would recommend regular inspection of the blast mains, inclusive of all joints and flanges. There are only a few plants where such inspection is made regularly every month. Also you will find at each inspection that some repairs are needed at the bustle pipe, blowstocks, and blowpipes. If there is a leak of only a square millimeter, it must be attended to at once. In such case welding is often very convenient. Often much air is lost by leaky, cold, and hot blast valves. One of the works has built with good success double valves—one after the other—to replace the single valves.

The last point for saving of fuel which I wish to mention, is the spare blowing engine, which is kept warmed up in case of necessity and which costs in a year hundreds of thousands in steam. The Commission has strongly recommended to shut down these and install in their place fans which blow only a few inches of water and which are sufficient to start the furnace again after a complete shut-down.

Discussion.

Manager Jaeger—Bochum: Dr. Rummel stated in the beginning of his paper that we should attempt to blow more blast in order to avoid variation in the quantity of blast furnace gas. I believe that this is already being done for quite some time at all those works where it is necessary to pay especial attention to the supply of blast furnace gas for the whole plant. Regarding blast saving; would say that this point is of extraordinary importance. We have in our works at present a yearly loss of from two and one half million to two and eight-tenth million marks through blast leakage, notwithstanding that the losses have been reduced during the last few years about 15 per cent.

Manager Harr—Hoerde: Dr. Rummel has stated that credit given for surplus blast furnace gas at most works is too small. This is right without doubt. The question is—Why is this credit set so low? The answer is this—Because the quantities furnished are so irregular. The other departments of the works have to be so equipped that they can fall back at any time upon reserve apparatus. The blast furnace man cannot help this; he has to look out first for himself in order to keep his plant running properly and to avoid interruptions which might be more costly. Just on account of the great variation in the volume of the gas which can be furnished to outside departments the credit is so low and not as high as it really ought to be. I express the hope, however, that the day will come when we can make more uniform deliveries of gas. I, therefore, feel thankful that our attention has been drawn to various matters which will help us to make progress. Unfortunately, it is not possible for all of us to install such an enormous gas holder as the one installed at Ilsede. We have to do the best we can with our means.

The suggestion regarding the idle periods in the operation of mills is very good. I have heard from other plants that they are getting great savings in this manner. The idea is very obvious but I will tell you that it does not work with us. And why? Only because the men do not want to help along. The workmen still rule in a great many points. Not everywhere do they agree to a second turn after a pause of four hours. One turn would end at midnight or would begin at midnight. This is too inconvenient for the men. They even decline to work Saturday nights; therefore you will observe in passing our plant that almost every night enormous amounts of blast furnace gas are bled, burning like an enormous torch, while during the day we are short of gas. It is even worse in the night from Sunday to Monday, when, besides the blast furnace gas, millions of cubic feet of the valuable coke oven gas are bled because the gas holder has not sufficient capacity to store it.

We have tried, I do not know how often, to make it clear to our men what enormous National values are destroyed through their refusal. The labor leaders see it and admit it but their influence upon the masses is not sufficient to allow us to make better arrangements.

Manager Dr. Hartman—Ilsede: Dr. Rummel has told us that it is the duty of the blast furnace man to absorb in his own department the peaks; that means, the time at which there is a surplus of gas and that he should deliver to his colleagues in the other departments, which use blast furnace gas, the remaining uniform quantities of gas. Dr. Rummel also told us that we could find a way to absorb the peaks by properly operating the stoves. That is true, and there are quite a number of simple means. For instance, we have an arrangement in Ilsede which shows in all engine houses and at all blast furnaces and, if necessary, also at each group of stoves, when a blast furnace casts or is checked. There is at all furnaces and at all engine houses, a box at a place where it can be easily observed. This box has as many pigeon holes as there are blast furnaces. The pigeon holes carry the number of the furnaces. The front wall of the pigeon hole consists of a tin plate in which the several blast furnace numbers are cut out. Behind this plate is a colored glass which is lighted by an electric light behind it and shows the number very plainly for a long distance. All these boxes are connected by wires. If one furnace casts, for instance, Furnace No. 4, then the blower at Furnace No. 4 sets the switch at his furnace and at all furnaces and at all engine rooms No. 4 is shown and also at all groups of stoves. This signal means Furnace No. 4 casts. Now it is not permitted to any other furnace to check. It is not permitted to change stoves and it means attention for the engineers at the engine houses and they watch the pressure. If the pressure of the blast, on account of checking of the furnace, increases at the other furnaces, then this will be only temporary and the other furnaces are getting more blast, as has been proposed purposely by Dr. Rummel. Of course, this only holds good in such plants where all furnaces receive their blast from the same blast header, as is the practice at our plant. The stove men are instructed to change the air supply at the stove burners according to the prevailing gas pressure. It is doubtful if they do this also always at night; at any rate I doubt it. But we obtain a certain amount of uniformity in the use of blast furnace gas at the furnace itself. This uniformity can still further be improved if the individual stoves for the several blast furnaces are changed on a time schedule; for instance—

Stoves of Furnace No. 1 are changed at
9:15 — 10:15 — 11:15, and so on

Stoves of Furnace No. 2 are changed at
9:30 — 10:30 — 11:30, and so on

Stoves of Furnace No. 3 are changed at
9:45 — 10:45 — 11:45, and so on

Stoves of Furnace No. 4 are changed at
10 — 11 — 12, and so on

In this way the change of stoves is distributed uniformly and if there are no other disturbances, we have a fairly regular gas consumption.

At the last visit of the Commission for Fuel Saving at Ilsede I have pointed out to these gentlemen that we have succeeded to quite some extent to use the stoves as heat reservoirs; that is, that we heat the stoves up to the limit as often as we can at such times when we have a gas surplus and that at such times when there is a great demand for gas in other departments we either do not fire any gas at all or but only very little at the stoves. I have shown these gentlemen that in Ilsede, during the time of greatest demand, 45 per cent and more of the total production of blast furnace gas was turned over into electric energy and that only 19 per cent to 20 per cent was left for heating the blast.

There is not a blast furnace man, I am sure, who will agree altogether with the proposals of Dr. Rummel and will be good enough to furnish to other departments a most liberal and uniform volume of gas and at the same time suffer from lack of gas in his own department. The blast furnace man has to look out for his furnaces first and he has to have sufficient reserve at all times for all contingencies. I do not believe that this latter point can be changed.

Manager Zillgen—Wetzlar: I cannot follow Manager Hartman in what he meant regarding the uniform changing of stoves. I think it is necessary to maintain in the stoves a certain final temperature; therefore, I would not agree to change stoves at a certain predetermined time. I do not believe that we would obtain good results this way. We are making very extended use in other departments of blast furnace gas and we are absolutely of the opinion that the stoves are the best heat reservoirs and that they have to absorb the peaks and we are at it now to install gas pressure regulators for furnishing uniform pressure of gas to the other departments. We will also equip the stoves with differential-pressure regulators so that we will be in a position to regulate the air supply for the stoves to conform to the gas quantities when the gas pressure varies. We have already attained good results in trying this system and we have a much more regular pressure curve in the other departments than we had formerly.

Manager Schmidt—Oberhausen: In connection with gas economy, I would like to mention the following: Statements have been made here regarding the consumption of gas by the stoves which vary very considerably. The values vary between 18 per cent and 30 per cent. In our works we have lately paid much more attention to the economical use of blast furnace gas and we have accomplished a good deal. The blast furnace man has been given to understand that it is not so necessary to keep down the coke consumption as was the case in former years because we have been arriving at the conclusion that saving of coke is not the most economical thing to do for the whole plant. The result is that the blast furnaces are used to some extent now as producers, because we are not working any more with such high blast temperatures. This allows us to burn more coke. I would recommend to those works where they use only 18 per cent of blast furnace gas for their stoves to compare their blast temperatures with those of former years where the stoves used more gas and they will find that also their coke consumption per ton of iron has risen accordingly.

Dr. A. Wagner—Duisburg: I want to speak regarding the suggestion of Dr. Rummel to use the stoves as heat reservoirs for absorbing the peaks. I do not consider the use of the stoves for this purpose as ideal. It is a better solution if it can be done and as has been done, according to my knowledge, first at the Duisburg Copper Works. The best and most economical user of the peaks is the turbine. The peaks, which are the result of irregular consumption of gas, can be absorbed without any trouble by the boiler plants and turbines and the power can be taken care of through supply of current to the municipal power stations. According to my opinion, there is a very good field here for the fuel engineer and the central station engineer in particular. I have heard of a second case where Rheinische Stahlwerke have entered into negotiations with the City of Duisburg in order to turn over their surplus gas at their Works in Meiderich on Sundays. In return, the works of the company situated at Duisburg take current during the week from the municipal plant and this current is partially paid for by the power supplied by the works. In most cases there would be no trouble to find buyers for current. I can very well imagine that, for instance, a city like Duisburg would shut down their central power station on Sundays and take all their current from the mills. Or, better still, that the mills would at all times be in connection with the city power station and give continually their surplus current to the city. Cities, I believe, will be only too glad to avail themselves of such an arrangement.

I believe I do not give away any secrets if I tell you that we sell our current to the city for the value of the coal equivalent of our gas. The price which the city pays is, therefore, very small. While the city charges from two to two and a half marks per kw hour, we furnish to the city the kw hour for three tenths of a mark. We make money by this arrangement and the city makes much more money.

Distribution of Tar Recovery From By-Product Coke Oven Gas

Some Interesting Experimental Work on the Recovery of Tar Is Tabulated—Distribution Figures Are Given.

By FREDERICK M. WASHBURN and GEORGE E. MUNS*

AT the by-product coke plant of the Wisconsin Steel Works, located at South Chicago, Ill., an investigation was made into the quantity and composition of the tar removed at various points along the path of the gas, resulting in the data given below.

The plant consists of two batteries, each of 44 Wilputte ovens, together with complete direct type by-product recovery apparatus. The gas is conducted by goosenecks from the top of the oven through a mushroom valve and into the collecting main. At the mushroom valve it meets a spray of flushing liquor, which prevents pitching of the valve seats. The gas is then drawn through the suction mains where it is again sprayed with flushing liquor and conducted to primary coolers, which are of standard indirect type, water tube design. From this point it passes through Root positive exhausters, which force it through the tar extractor and other apparatus for the recovery of by-products.

Fig. 1 shows diagrammatically the flow of gas from the ovens through the gas mains and apparatus, and the points at which condensed or extracted tar is drawn off for subsequent separation and storage. Temperature and pressure conditions are shown by notation at these points.

All tests were run under uniform operating conditions, with temperatures and pressures normal, with an average net coking time of 22 hours 51 minutes, and with a coal mixture of 95 per cent Benham (high volatile) and 5 per cent Pocahontas (low volatile) coal. Average tar and gas yields per ton of dry coal charged were taken over a period of 24 days operating at this coking time, and amounted to 11.39 gallons of tar and 11,365 cu. ft. of gas. All figures in tar gallonage are calculated on a moisture free basis because of the wide variation in moisture content of different tars separated.

The general plan of the test was to actually measure the tar recovered at the different points for a definite period of time, noting the total volume of gas handled during that time, and obtaining a representative sample for analysis of the tar produced. Lack of tank space made the actual running time of the tests shorter than was expected, but good checks were obtained by repeating. In detail, the procedure was as follows:

Test A—P. & A. Tar Extractors.

The hot drain tank was isolated and the tar separated by the P. & A.'s discharged into this tank. Measurements were made at the start and finish of each run, and gallonage determined from the tank calibration and measurements. The sample for analysis was taken from the seal pot overflow.

Test B—Gas Chamber (After Exhauster).

The gas chamber was emptied at the start. During the run the condensate was drained into tarred barrels at regular intervals, and at the finish of the run. The gallonage was determined from the weight and specific gravity of the tar. The sample for analysis was taken from the barrels.

Test C—Exhauster Drain (Section Side).

The exhauster drains were sealed off in 500-gal. cylindrical tubs, which were measured at start and finish of run, and the gallonage determined by calibration and measurements. The sample for analysis was taken from the tubs.

Test D—Primary Coolers.

The drains from the primary coolers were discharged into the isolated hot drain tank, which was measured at the start and finish of the run. The gallonage was determined by the tank measurements and calibration. The samples for analysis were taken at the siphon pot.

Test E—Suction and Collecting Mains.

This tar occurred in small quantities in comparatively large quantities of liquor, and owing to the difficulty of measurement, the amount of tar separated here was obtained by the difference between the previous tests and the total production. Separate samples for analysis were taken from the suction and collecting mains. In order to secure an uncontaminated sample, an all liquor flush was circulated for four hours before the test and during the test.

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*Mr. Washburn is coke plant chemist and Mr. Muns general by-product foreman at the plant of the Wisconsin Steel Works.

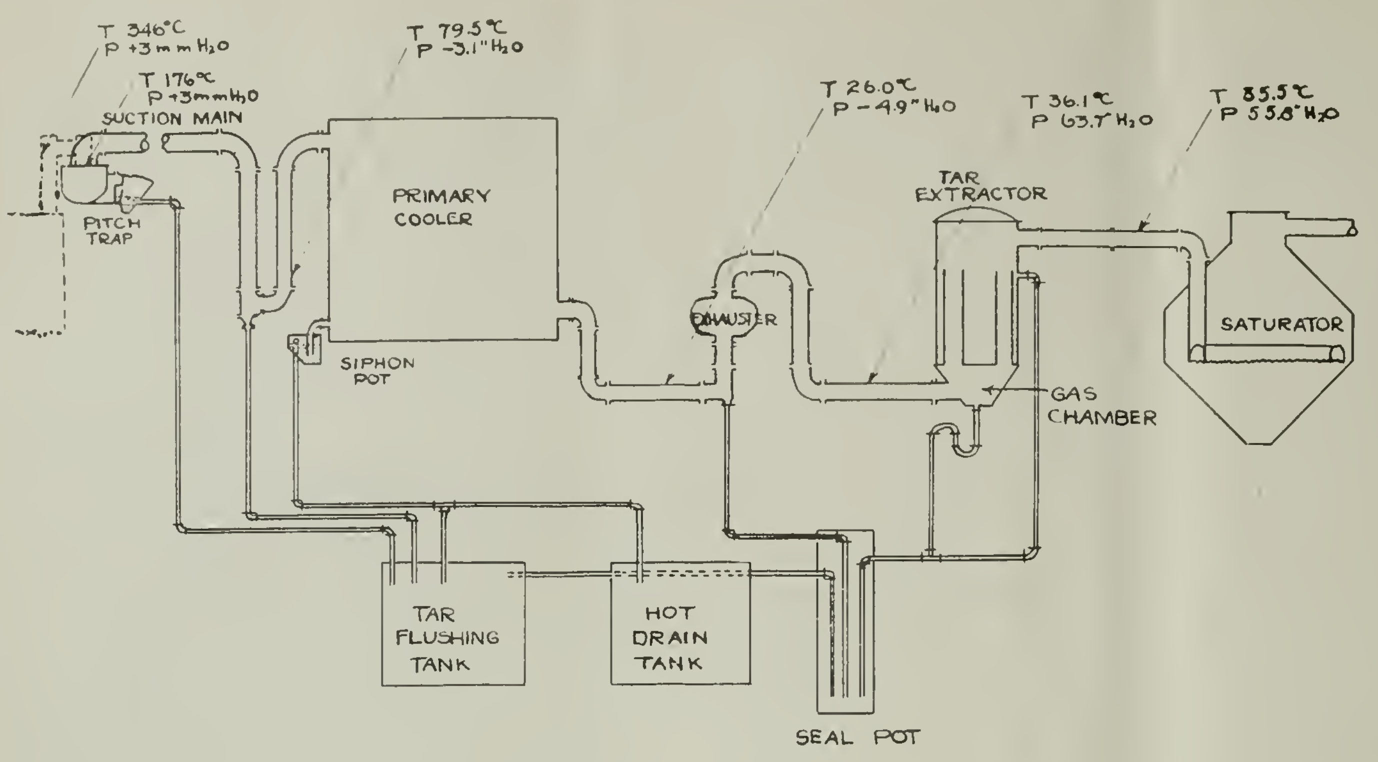

Fig. 1.

Moisture determinations were made on all samples except those from the suction and collecting mains. All samples were dehydrated, and specific gravity, free carbon and distillation determinations made on the dehydrated tars The specific gravity determinations were made with a Westphal balance with the exception of the samples from the suction and collecting mains, which were too viscous for this method, so a tar specific gravity bottle was used. The distillations were made on a 100 cc. sample in a 200 cc. side neck distillation flask connected to a vertical condenser.

Table I—Distribution of Tar

Test	Location	Duration of Run	Gas Passed M. ft.³	Gals. Tar Obtained	Gals. Tar per M. ft.³ of Gas	Percentage of Total Tar Production
A	P.&A. Tar Extractor..	325	2451.5	179.63	.0732	7.30
B	Gas Chamber	325	2451.5	49 50	.0202	2.01
C	Exhauster	325	2451.5	433.26	.1767	17.64
D	Primary Cooler	120	867.5	354.96	.4092	40.84
E	Suction Main				.3227	32.21
F	Collecting Main					

Table II—Analysis of Tar

Test	Moisture	Sp.Gr 15.5°C. / 15.5°	Free Carbon	Under 110°C.	110° / 170°	170° / 235°	235° / 270°	270° / 300°	Residue & Loss
A	4.45	1.135	4.21	1.5%	6.0	39.5	9.5	6.5	37.0
B	.47	1.140	3.45	1.0	3.0	30.0	10.5	5 5	50.0
C	6.50	1.121	3.44	1.5	5.5	33.0	10 0	8 0	42.0
D	5.60	1.140	3.48	.5	5.0	35.5	11.0	6 0	42.0
E	...	1.229	11.94	..	..	2.5	4.0	6.0	87.5
F	...	1.202	10.92	..	..	5.0	6.0	7.0	82.0

The tar obtained from the exhauster drains (Test C) probably represents separated tar mechanically carried over from the primary coolers, as from Table II it may be seen that Samples C and D are very similar in composition. Sample C is a slightly lighter tar than Sample D, which would naturally follow, since Sample D is composed of tar separated in all sections of the primary coolers, while Sample C probably consists mainly of tar from the last or coldest section. From Table I it may be seen that over 90 per cent of the tar present in the gas is removed during its passage through the mains and primary coolers. Two per cent of the remaining tar is removed by passage through the exhauster, leaving only a little over 7 per cent to be removed by the tar extractor. The free carbon and residues on Samples E and F are extremely high due to coal dust mechanically carried over from the ovens. This coal dust is subsequently removed in a pitch trap. The tar from Tests E and F is very heavy and viscous, since they were separated at a high temperature. As the separation temperature is lowered, the tars become lighter and more fluid. Due to the increase in pressure and temperature caused by passage through the exhauster, a heavier tar is separated from the gas chamber (Test B). Up to this point the separation of tar has been governed mainly by temperature and pressure conditions, but in the P. & A. tar extractor, the temperature and pressure cease to play such an important part, for the mechanical action of the impingement of the gas on a surface causes the separation. The tar separated from the tar extractor (Test A) represents practically the last traces of tar in the gas, and is the tar having the greatest percentage of oils and least pitch residue of any of the tars tested.

STEEL COMPANIES CONSOLIDATE

Arrangements have been made for the consolidation of the Electric Alloy Steel Company of Youngstown and The Atlas Crucible Steel Company of Dunkirk, N. Y. Approval of the respective boards of directors is all that is necessary to close the deal.

Use and Abuse of Powdered Fuel for Stationary Boilers

Any Great Advance in Combined Boiler and Furnace Efficiency Will Depend Largely Upon the Full Utilization of Radiant Heat.

By JOHN E. MUHLFELD*

THE first successful use of powdered fuel was in cement kilns. As the requirements in efficiency and economy for that purpose were not such as to necessitate complete combustion in a short distance, nor any particular disposal of the non-combustible due to the latter being reclaimed with the product, and as the price of coal at that time was relatively cheap, these factors were of no great import.

When the burning of powdered fuel was introduced in stationary boiler furnaces located in cities and towns, entirely different and more difficult conditions were encountered, and numerous troubles in pulverization, storage, conveying and feeding, as well as due to the inability to secure quick and complete combustion in short travel and small space, and to overcome the difficulties resulting from the unconsumed combustible and the ash accumulating in the boiler and furnaces in the form of slag, honeycomb or fine dust, as well as being discharged from the stack, became immediately apparent. As a result, during the past ten years a great deal of information has been presented before various engineering societies and published in technical and trade journals and papers as to how these difficulties could be overcome, but inasmuch as a large amount of this information has been compiled by people who have not been directly responsible for devising means, methods and processes for the development, installation and operation of powdered coal, the broadcasting of a lot of this misleading, unfounded, and purely theoretical information has resulted in many false impressions and in numerous installations of powdered fuel burning equipment with attendant high initial investment and operating costs, and performance disappointments, which could have been avoided by competent engineering analyses and supervision.

Hazard.

Danger from the use of powdered fuel, more particularly during the early stages of its development, was largely due to the drying and pulverization equipment and processes used, the mixing of the powdered fuel and air in a combustible state for conveyance and distribution for long distances prior to storage or feeding to the furnace, and to the lack of practical knowledge, instructions and experience.

A number of systems are still in use and being installed which involve a certain element of danger when there is a failure to observe the proper instructions, but the more recent developments, whereby the necessity for direct or indirect heat drying prior to powdering is now made unnecessary, and the powdered fuel can be conveyed direct from the pulverizing equipment to the furnace without intermediate storage or distribution, practically eliminate the liability for spontaneous combustion, fires or explosions that may be caused by negligence, and reduce the hazard below that which obtains with the use of fuel oil or gas.

Preparation and Storage.

The investment, upkeep and operating cost for the preparation and storage of fuel in powdered form has been the greatest single factor in retarding its more extended use, particularly in plants using less than an average of 80 tons of fuel daily where the greater capacity, efficiency and economy obtainable do not justify the increased fixed charge. This has been due principally to the fact that the majority of the pulverizing mills, which are in use and being marketed today, were originally designed for the powdering of cement clinker, ores and paints and not adapted to fuel. Pulverizing equipment of this kind, wherein the sizing of the product is dependent upon its passage through screens, was largely responsible for the use of direct and indirect heat fuel dryers and for the early claims that fuel for pulverization should be dried to a moisture content of not less than one per cent. While the development of the air-separation types of pulverizers brought about a considerable improvement in this regard, they did not, particularly for the reason of the first cost and the cost for operation, greatly relieve the situation, and it has remained for a self-contained unit system of pulverization, which is now being developed along efficient and practical lines, to enable the elimination of large and expensive buildings, storage bins elevating and conveying equipment, dryers, pulverizers, and all other intermediate and accessory machinery.

Another retarding factor and which resulted from the use of powdered coal in cement kilns, and experimentally in steam locomotives, has been the general impression that the fuel must be of such fineness that at least 95 per cent will pass through a 100-mesh, and at least 85 per cent through a 200-mesh screen. The cost to produce this degree of pulverization by direct or indirect heat drying and milling is substantially higher than the cost for combination air-drying and milling to a fineness of about 90 per cent through 100-mesh, and 70 to 75 per cent through 200-mesh, which it has been found produces entirely satisfactory results with bituminous coals and lignites.

Distribution.

The generally designed preparation plant consisting of storage, drying, pulverizing, elevating, conveying and other intermediate apparatus requires a considerable amount of equipment, power and maintenance for the handling and distribution of the raw, dried and powdered fuel. Where systems which combine and distribute combustible mixtures of powdered coal and air are installed, the power requirement for such distribution and circulation is also a large additional item of expense.

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*Consulting Engineer, New York City.

By substituting for such installations a self-contained unit system of air-drying, pulverizing and distribution, a much less expensive and complicated and a more efficient and economical operating arrangement can be provided.

Feeders and Burners.

Much time and money has been and is still being expended in devising feeders and burners for introducing powdered fuel into stationary boiler furnaces, whereas any simple device which will continuously and uniformly introduce a predetermined supply of powdered fuel and air mixture into the furnace will successfully meet all requirements.

Furnaces and Boiler Baffles.

Various installations and tests made during the past ten years in the burning of powdered anthracite and bituminous coal and lignite, on different types of boilers in combination with various designs of furnaces and baffles, have erroneously led to the general opinion that only vertically baffled boilers are suitable for the burning of powdered fuels in suspension. The reason for this may be attributed to the greater average depth of the combustion space found in combination with vertically baffled boilers, as well as the permissible use of a vertically and downwardly injected fuel stream into a preliminary combustion chamber leading to the furnace proper, and which arrangement provides for a relatively long flameway and time element prior to the absorption of the heat combustion. Vertically baffled boilers, with the usual means and methods in vogue, have also reduced the liability for the accumulation of honeycomb and ash dust in the boiler tube passes.

Early experiments on horizontally and vertically baffled boilers of different types indicated that with suitable furnace and soot blower equipment the evaporation results from the horizontally baffled boilers were equivalent if not greater than for vertically baffled boilers, the reason for this being a more favorable arrangement of heat absorbing and radiating walls of the furnace for the purpose of flame and radiant heat propagation.

A stationary boiler installation is now being made in the Central West where the horizontal system of baffling, in combination with improved fuel preparing, burning and furnace equipment, is being introduced for the use of powdered fuel, and the testing out of this equipment will soon develop as to the economy in first cost and for upkeep and operation, practicability and general utility of this system as compared with the other most successful systems now in use.

Combustion.

Almost any practical means and methods may be employed to bring about the combustion of powdered fuel, but it remains for a scientifically correct combination of fuel, preparation, fuel and air mixture, feeding, furnace, induction air, draft, boiler baffling, soot blowers, and gas areas to produce an oxidizing atmosphere in the furnace at all times, in order to produce efficient "ferric oxide" instead of deficient "ferrous sulphide" chemical reaction or combustion results. This process of chemical reaction having been completed, there must then be such combination of air and flame-way travel as to insure proper CO_2, heat and ash control if satisfactory results are to be accomplished. Frequently one or more of these essential factors are missing due to either the equipment or the methods of operation.

Brickwork Wear and Tear.

The destructive agencies of temperature, slag, abrasion, corrosion and eutectic action, all of which must be resisted by the refractory materials used in the furnace walls and baffles, have, in many instances, been a serious obstacle to a continuation of the use of powdered coal. Too much importance cannot be placed upon the kind and installation of refractory, arrangement of the heat absorbing and radiating walls of the furnaces and baffles, calculation and adjustment of the gas areas through the boiler, and especially to the adjustment of the flameways in a manner to avoid heat concentration and scouring action on any of the refractory walls.

The ordinary feeding and burning equipment is such that the control of the flameway and the combustion is dependent largely upon the velocity with which the fuel mixture enters the furnace, and on the regulation of the stack draft and air. Such arrangements cannot produce the most satisfactory combustion, refractory and evaporation results and the provision of means for easily, quickly and closely regulating the direction and volume of the flameways in the furnace is a most essential but greatly overlooked adjunct.

Ash.

Pulverization of fuel necessarily combines with it the non-combustible, the fine particles of which are either deposited in the furnace proper, on the boiler surfaces and baffles, or otherwise pass through the stack to the atmosphere. Those particles which are deposited on the boiler surfaces and baffles can, with proper mechanical facilities, be readily blown off, and those collecting in the furnace may be removed in the usual way, unless, due to unsuitable burning or furnace equipment, they are allowed to fuse into slag.

Great stress is laid by many power plant and stoker builders and operators on the percentage of the ash which finds its way to the atmosphere through the stack, but from observations made during the past five years, of the stack of the Oneida Street Power Plant of the Milwaukee Electric Railway & Light Company, Milwaukee, Wis., when carrying the load on each the powdered fuel and the stoker fired boilers, sufficient practical evidence is available to show that the impalpable ash particles emitted from the former are decidedly less objectionable than the smoke and cinders emitted from the latter. In fact, as yet no evidence has been found of the ash which comes from the powdered fuel equipped boilers. It should be remembered, however, that the system employed for the burning of powdered fuel has much to do with the results to be obtained in this direction, and that several boiler plants are now, or have been operated with powdered fuel systems where not only the ash, but also the unconsumed fuel particles emitted from the stacks have been a serious menace. Even in such cases there has not been the objection such as can be raised to the smoke and cinders carried out of the stack by stationary or traveling grate, or retort, stoker fired boilers, especially when operated under peak loads.

Slag.

With powdered fuel burning furnaces, slag is the result of the fine molten or dry particles of ash deposited on the furnace floor being retained in a high temperature location, with resulting fusing into a conglomerate mass, and these collections of slag have been the cause for considerable experimentation, annoyance and expense. In some cases, extreme measures have been resorted to, such as the installation of undesirable so-called water screens, supplementary to the boiler proper, located just above the furnace floors, for the purpose of introducing a cooling effect at that point to prevent slagging, but these, through the interposition of heat-absorbing and combustion cooling surfaces, invariably reduce the furnace efficiency otherwise obtainable. Also air-cooled furnace floors, molten slag hoppers, steam sprays, and like devices have in some cases been resorted to, but without satisfactory results.

A proper analysis of slag troubles will determine that suitable furnace design, production of "ferric oxide" rather than "ferrous sulphide" combustion, and regulation of CO_2 is all that is required to eliminate troublesome slag conditions.

Pre-Heating of Combustion Area.

With the usual powdered fuel installations the preheating of air, for the purpose of advancing combustion, unless it can be accomplished by means of waste heat in combination with simplified means and methods, is not productive of any considerable net economy. However, with more adaptable furnace and combination pressure and induction combustion air systems a simplified arrangement of furnace design and construction can be devised whereby pre-heated air may be more economically utilized.

Superheat.

The regulation of superheat temperatures, more particularly where the superheaters are of the radiant heat type, or otherwise located in the furnace brickwork instead of the boiler gas passages, is a factor not to be overlooked, for the reason that lack of superheat temperature is bound to be reflected in machinery, lubrication, efficiency and upkeep troubles, and with the use of powdered fuel it is most important that an automatic and simple device for such regulation be provided

Conclusions.

Central power station, industrial boiler plant, and marine and locomotive boiler operations have long since established the desirability, efficiency and economy of using oil or gas for steam generation, but the gradual depletion of such fuels for these purposes, the increasing cost for all gaseous, liquid and solid combustibles, and the accentuated public and industrial interest in the necessity for greater conservation and utilization of fuel by-products or deposits which have not heretofore been workable to commercial advantage, will now make necessary the use of the practically inexhaustible stores of inferior bituminous and anthracite fuels and lignites in the most effective manner, and which, in powdered form, enables them to be burned in suspension, the same as natural gas and fuel oil

Any great advance in combined boiler and furnace efficiency will depend largely upon the full utilization of radiant heat. When solid fuels are burned on grates or in retorts the heat given out is radiant only until the first evaporation surfaces are reached, whereas with powdered fuel burned in suspension, the solid and gaseous products of combustion, as well as the increased refractory surfaces, project radiant heat direct to a relatively large proportion of the heating surfaces and this enables an increase of from 20 to 30 per cent in the otherwise obtainable thermal efficiency of those boiler portions which are directly affected. In fact, the use of powdered fuel, as compared with stoker firing, has shown higher overload and average working boiler capacities, greater efficiencies at the higher ratings, lower banking and stand-by period fuel consumption, reduction of nonproductive labor for ash-handling and boiler and furnace upkeep, elimination of the smoke and cinder nuisances, ability to use available supplies of cheap, low-grade fuels, and practicability to burn gaseous, liquid or solid fuels in combination or independently.

While the necessity for the special preparation of the powdered fuel has been a retarding factor in its more extended use, the past ten years' experimentation has developed that separate and costly fuel preparing, storage and distributing plants are unnecessary adjuncts for the use of powdered fuel, as the equipment for the latter can now be made a self-contained part of the boiler plant and will require no more under-cover space than for the installation of modern grate or retort stokers.

Waste Heat Boilers in Steel Plants

All Modern Waste Heat Boilers, Applied to Such Operations as Formerly Depended on Natural Draft, Must Be Equipped With Induced Draft Fans.

By J. C. HAYES*

THE fact that there has been a remarkable revival of interest in waste heat boiler equipment in the past few months is a logical development in view of the sequence of events as affecting waste heat boiler practice in this country.

In a paper read before the American Iron & Steel Institute in 1915, Mr. C. J. Bacon—who was steam engineer at the South Chicago plant of the Illinois Steel Company where most of the experimental work was done—gave the results of the preliminary work, together with an outline of the possibilities of further savings by taking advantage of the knowledge gained in the development work up to that time.

In a discussion of this paper Dr. D. S. Jacobus of the Babcock & Wilcox Company stated that the conditions indicated in the early stages of Mr. Bacon's work resulted in the Babcock & Wilcox Company making a careful study in order to determine the best means of applying boilers to this class of service, and that the investigations resulted in a radical change in their waste heat practice.

It may thus be seen that the waste heat boiler as it is known today was only fairly well established as an essential to economical open hearth practice, when the war demand for steel, especially plates, forced the consideration of tonnage with apparent disregard for the cost of production.

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*Plant Engineer, Freyn, Brassert & Company, Chicago, Ill.

Of one thing we may be sure—the cost of fuel will always be a major item in the cost of any product requiring heat for its production, and the waste heat boiler as an institution is here to stay, especially as it has been shown that any process in which steam is used and in which the equivalent of 20,000 pounds of gas an hour at a temperature of 900 deg. F. or more is now wasted may look forward to the use of a waste heat boiler as a means of reducing manufacturing costs.

Practically all the recently built open hearth furnaces, as well as many other types of furnaces, either have waste heat boilers as part of the original installation or have space provided in the design for future boilers.

A boiler designed for the recovery of waste heat from comparatively low temperature gases must be one in which the gases pass across the heating surface at relatively high velocity when compared with the ordinary direct fired boiler.

In a boiler using direct fuel, as much as 65 per cent of the heat may be transferred by radiation, or in other words, may be absorbed directly by the tubes from the incandescent fuel bed, arches and furnace walls. It is generally conceded that heat thus absorbed varies directly as the fourth power of the temperature difference between the tubes and the radiating surface. In the waste heat boiler, the heat thus available is less than one-tenth of that available in a direct fired boiler because of the absence of intensely heated surface, and the further fact that much less of the heating surface is exposed to the action of the radiant heat from the incoming gas passages.

The success of the waste heat boiler is therefore dependent almost entirely on the heat extracted from the gas by convection or direct contact of the gas with the heating surface.

In order to accomplish the maximum contact of hot gas and tube surface, there must be a positive scrubbing or tumbling action of the gas which is accomplished by the high velocity at which it is passed across or through the tubes, thereby preventing the natural tendency of the gas to form an insulating film of cool gas close to the heating surface and allow a hotter center, or core, to pass on without giving up its heat.

It was the demonstration of the effect of high velocity on heat transfer that brought about the radical change in waste heat boiler practice. The failure to recognize, or the inability to comply with the high velocity requirements in waste heat practice, was undoubtedly the cause of many failures in the early attempts to recover waste heat from industrial furnace gases, especially where the temperature of the waste gas was below 1800 deg. F. Many forges and melting furnaces were equipped with various types of waste heat boilers and considerable recovery of heat in the form of steam was noted in such installations as approximated straight coal fired conditions, that is, where waste gases were at a temperature of over 1800 deg. F. and the natural draft was sufficient to pull the gas through the boiler and still provide enough draft for the heating furnace.

Such boilers were generally one-pass fire or water tube boilers set vertically over the furnace and exhausted the gas directly to superimposed stacks. The waste gases from some of these furnaces were as high as 2400 deg. F. and the recovery was good on account of the relatively large amount of heat absorbed by direct radiation.

All modern waste heat boilers, applied to such operations as formerly depended on natural draft, must be equipped with induced draft fans. Ordinarily, not over 8 per cent of the steam generated by a boiler is required for driving the fan, and in cases where the exhaust steam can be used to heat feed water, the net loss chargeable to the operation is less than two per cent of the total evaporation.

A 75-ton open hearth furnace in which 70,000 lbs. of waste gas is available at a temperature of 1200 deg. F. will yield a net recovery of 354 Bo. hp. per hour in steam at 160 lbs. per sq. in. pressure and 100 deg. superheat when equipped with a standard superheater and a two-pass boiler having 5,700 sq. ft. of heating surface. Under these conditions the gas will be reduced to a final temperature of 520 deg. F. and the draft loss through the boiler proper will be 1.8 inches head of water. The fan for this particular installation will have to handle the gas at a differential of 2.5 inches head of water to make up for frictional losses in the valves, flues and superheater.

In certain cases it may be profitable to reduce the final gas temperature much lower than 520 deg. F. The test data now available for calculating the performance of waste heat boilers is such that the amount of heat recoverable under any given set of conditions may be accurately predicted, and the advisability of obtaining final temperatures below, say, 520 deg. F. is merely a matter of capitalizing the extra investment required for extending the heating surface and making allowance for the added power required for driving the fan.

There are a number of fire tube boilers now in waste heat service in which final gas temperatures average less than 400 deg. F. These are three-pass boilers in which the last pass serves as an economizer element. The size of tubes and amount of heating surface in a boiler for any given weight of gas is ordinarily based on reducing the temperature of the gas to a minimum of 450 deg. F. and a maximum of 550 deg. F. Final temperatures outside this range are not economical except in such cases as the investment in an economizer element is considered.

Any type of water tube boiler that is satisfactory for straight fire service may be adapted to waste heat service by arranging the baffles so as to increase the gas velocity, but it has been shown that those types in which the gas passes at right angles to the center line of the tubes, or approximately so, will give better heat transfer than those in which the flow of gas is parellel to the center line of the tubes. While this is also true to some extent in direct fired boilers, the particular advantage in waste heat practice is on account of the relatively large portion of the heat that is absorbed by convection in the waste heat boiler.

On account of the higher gas pressure differences between passes, the baffling on water tube boilers must be particularly tight. Improvements in the way of double walls, special shapes and monolithic baffles have recently been developed for this service.

Infiltration of air through brick walls is a greater source of loss in waste heat practice than in direct firing. For this reason particular attention must be paid to keeping the settings free from leaks. A number of water tube boilers have been installed with the settings entirely enclosed in steel plate.

In fire tube boilers air infiltration is practically nil, therefore the gas velocities may be greater and the consequent high differential between incoming and outgoing gas may be maintained over an extended steaming campaign with no danger of overloading the fan or losing heat on account of defective walls or baffles.

WITH THE EQUIPMENT MANUFACTURERS

New Operating Head Revolutionizes Operation of Soot Cleaners

A new device which, it is said, will revolutionize the operation of mechanical soot cleaners, has just been announced by the Vulcan Soot Cleaner Company of DuBois, Pa., manufacturers of Vulcan soot cleaners. It is claimed that the device is the newest and most advanced principle in soot cleaner operation, and is destined to insure a more thorough removal of soot than has been possible hitherto in many plants as a result of careless or too hasty use of the soot cleaning apparatus.

The device announced by the Vulcan Company is the new Vulcan ratchet operating head, illustrated in Fig. 1, the basic principle of which is automatically to limit the sweep of the soot cleaning element, to force the operator to operate the element in a step-by-step movement, and hence to insure that the steam jets have an opportunity to sweep over and thoroughly clean every part of the tube surfaces.

For many years a small percentage of soot cleaner owners have complained that soot cleaners did not thoroughly remove the soot accumulations. Investigation disclosed, in a majority of these cases, that the cleaning elements either were being rotated too fast or rotated by careless workmen through only a fraction of the full permissible sweep of the elements. As a result, the cleaner was prevented from doing its proper work, through failure to give the steam jets time enough to thoroughly clean the tube surfaces.

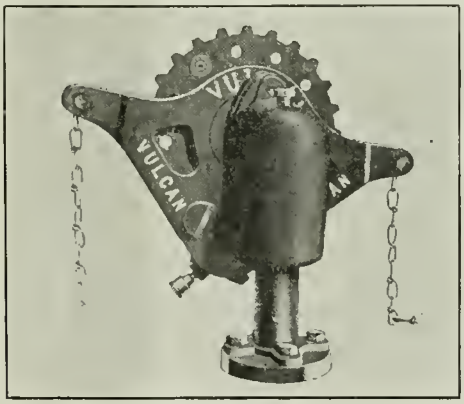

Fig. 1.

To correct this difficulty, to make soot cleaner operation more mechanical and less dependent upon the efficiency of the human factor in the boiler room, the new Vulcan ratchet operating head was designed and is now being placed upon the market.

The new head is so constructed that when the operator pulls the chain the element is rotated only a short distance and can be turned no farther until the ratchet frame has been returned to its original postion. Then, and only then, a pull on the chain causes the element to rotate another space. Between the lulls in operating the new head, the steam jets have an opportunity to concentrate upon a definite section of the tube surface for a length of time sufficient to insure a thorough removal of the soot. When the complete arc of rotation has been attained in one direction, which is limited by "stops" especially set for that purpose, the mechanism automatically reverses itself and the cleaning element moves back in the same manner through the same arc. Any soot that may have redeposited after the first rotation is completely removed on the backward travel.

In designing this ratchet operating head, the Vulcan engineers kept constantly before them the fundamental purpose of every soot cleaning apparatus, namely, to remove the soot thoroughly, and built their operating head with this purpose only in mind, regardless of the competency of the individual doing the actual work of handling the equipment. The net result is a device that takes the control of cleaning entirely out of the hands of the operator and places it solely in the ratchet operating head.

The Vulcan ratchet operating head possesses five features of paramount importance to the power plant engineer. These are:

(1) It absolutely prevents the man operating it from neglecting any part of the complete sweep of the cleaning element.

(2) It substitutes a uniform rate of speed of rotation, in a step-by-step movement, controlled almost entirely by the head itself, in place of the old irregular, uncertain rate controlled by the whim of the operator and his desire to get through with the job as quickly as possible.

(3) It assures a considerable saving in quantity of steam used, because the operator knows that he has to make the sweep only once in each direction and can stop when that has been completed.

(4) It provides the operator with a clearly defined task, instead of a vague and indefinite one.

(5) Above all, it entirely eliminates wrong methods of soot cleaning, and is an assurance of more satisfactory and thorough cleaning results.

The new head, as may be seen from the illustration, is remarkably simple and strong. Its action is positive and sure. There is not a part to slip out of place and thereby throw the whole device out of action. The chain is securely riveted to the ends of the ratchet frame and no amount of pulling or jerking will tear it loose.

This new Vulcan ratchet head is operated independently of the valve. Therefore, should the element operating mechanism accidentally fail during operation the whole cleaner system is not put out of commission while repairs are being made.

New Rolls For Steel Mills

The advance in the art of hot working iron and steel by means of rolls has been given an added impetus by the introduction of the **molybdenum** steel rolls of the Wheeling Mold and Foundry Company. The use of molybdenum steels during the past few years in the automobile industry had proved the desirable qualities of strength and resistance to shock. Experience in die and other hot working steels had developed another desirable quality in these steels; namely, resistance to the effect of hot work to a greater degree than in other commercial steels. Familiarity with these qualities led the Wheeling Mold and Foundry Company, with the cooperation of the Molybdenum Corporation of America, to experiment with similar steels for rolls.

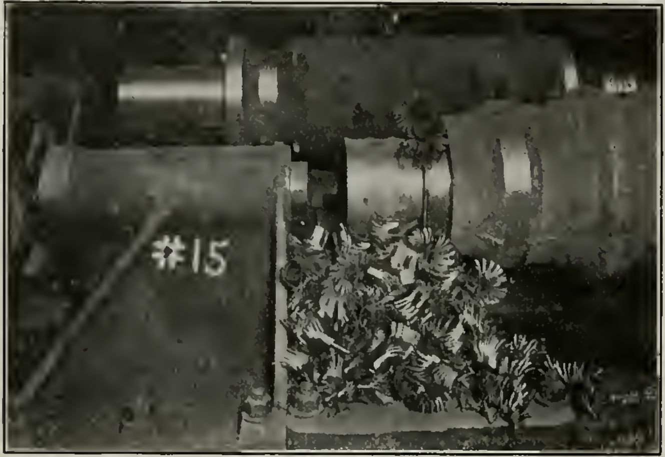

Fig. 1—This cut shows a molybdenum roll in the lathe and the turnings cut from it. It is particularly interesting to note that these turnings formed in highly blued, tough, strong springy spirals, indicating a similar quality in the steel, far superior to any that has been observed heretofore. The very noteworthy fact was encountered that, although these rolls developed a scleroscope hardness of 50 to a depth of about six inches, they still possessed the toughness of low carbon steel.

Experimental work was undertaken about the middle of 1920. Small electric furnace heats were made, cast and subjected to many different experimental heat treatments. The results of this research showed enough merit in the molybdenum steels to justify the solicitation of an order for a set of molybdenum rolls for practical mill test. The order was secured and the rolls made in June, 1921. Shop tests on these rolls, such as physical property tests and machining tests, etc., confirmed their opinion of the desirability of molybdenum rolls and their desire to push the matter further. Photographic evidence of the machining test is shown herewith.

Since these first rolls were made, the Company has developed the heat treatment processes to such an extent that with a slight difference in composition and heat treatment, they can produce rolls ideally adapted to any purpose from the strongest roughing roll to the hardest finishing roll. In each case the rolls are exceptionally tough and able to withstand an enormous amount of abuse and can be treated at the same time to show a hardness suitable for any mill condition. No other alloy steel is useful for so many places in rolling mills.

The two main characteristics desirable in rolls are resistance to wear, and strength. Resistance to wear is the result of a combination of hardness and toughness plus heat resisting properties. Molybdenum rolls possess these characteristics to a marked degree, to an extent, in fact, which should produce a two hundred per cent increased service over that of the carbon steel roll practice. A greatly increased number of dressings before the rolls are reduced to their smallest permissible diameter is possible from the known fact that these heat treated molybdenum rolls reduce side wear to a minimum and, therefore, necessitate small reductions in diameter to bring back the shape of the groove. When used as roughing rolls, the increased hardness and consequent resistance to wear, is not at the expense of proper mill practice. Experience shows the rolls to have a good bite and slippage is not encountered as is the case with the high carbon alloy steel rolls now in common use. In cases where ragging is necessary, the sharp corners hold up in a most satisfactory manner. When used in finishing rolls, the passes retain the shape of the section and produce a very smooth finish due to the continued absence of fire cracks, pits and other surface irregularities. In current practice an example can be cited where these molybdenum rolls have been used for very severe service in a small roughing stand. The excessive breakage was entirely eliminated and two hundred per cent increase in tonnage was secured per dressing with fifty

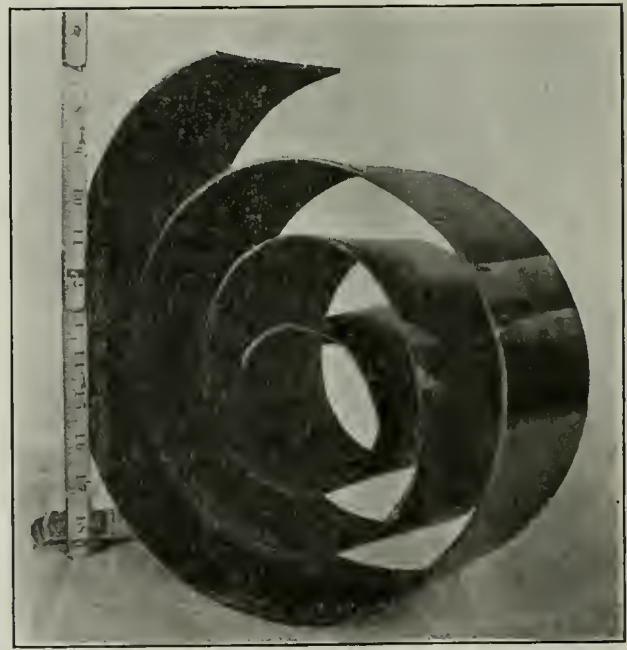

Fig. 2—This cut shows an individual turning which speaks for itself.

per cent less reduction in diameter.

It is believed that the use of molybdenum steel rolls will permit of a great increase in the size of the entering billet, possibly as much as thirty per cent, as well as to permit of an increased roll length in proportion to the diameter. In addition to the resistance to wear and the strength just mentioned, the molybdenum steel rolls possess great resistance to shocks. This characteristic will be appreciated in that it will assist in offsetting the occasional accidents that occur even in the best mill practice.

It must not be thought that these results have been obtaned in only a few cases. Many rolls have been made, varying in size from five hundred pounds to forty-five thousand pounds, with consistently satisfactory results in the foundry and steel plants. These rolls are proving themselves in service and daily new reports of satisfactory results are being received. In no case has there been a failure.

It would be well to state that molybdenum sand rolls and molybdenum chilled rolls are in service and to date are showing up very satisfactorily. In one case, molybdenum sand rolls have been thoroughly tested in a large billet mill and results obtained justified the adoption permanently of this type of roll. Somewhat the same qualities are brought out in the iron as in the steel rolls and equally excellent results are anticipated.

The Wheeling Mold and Foundry Company believe that the development of molybdenum rolls is the greatest stride forward in the roll industry in the last quarter century.

Centralized Control

There have been many examples to show the advantages and economic need of intelligent centralized control—in the hands of one power in which is concentrated the information and judgment best obtainable under the conditions.

Without such single directing force the Allies in the last year of the World War would scarcely have been able to defeat the Central Powers under the well directed leadership of Germany; and without such centralized control the Allies now stand wavering before the diplomatic attacks which beset the peace and bid fair to shatter the Treaty of Versailles.

A most interesting exposition of the possibilities of centralized control, indeed revolutionary in effect, is that of the air brake. Before its era a signal was given by the whistle on the locomotive and half a dozen men sprang to the hand wheels of the individual cars—sometimes they lagged a little or set the brakes too hard. Contrast this with the absolutely perfect control now in the hands of the engine driver. Is there need to ask what would become of our modern railway service without the air brake and its control valve in the cab of the locomotive?

Less absolutely essential, perhaps, but still of vital importance in the conservation of fuel, centralized control of combustion in our large power houses is fighting for recognition against the old time-honored methods which seem to have such a strong hold upon the minds of engineers.

From time to time important steps have been taken, one of the most noteworthy being the introduction of so-called "time-firing" where coal is used for fuel and it is fired by hand. This system, so far as the writer knows, was first introduced by Commander W. W. White, U. S. N., about 20 years ago in connection with "trial trips" of new naval vessels. These tests always included steaming for a considerable period at maximum power and speed, and it was absolutely essential that full steam pressure should be maintained at such times. Commander White had noted, under the old system, that some of the firemen kept good fires while others fired at infrequent periods and shoveled the coal into the furnaces to mountainous heights. So he worked out a plan by which, at a given signal, each fireman had to get up and "do something"—he went further and told him what to do. Each fire door was numbered, and the scheme so worked out that "firing," "raking" or "slicing" should come at a certain specified moment for a particular door. He also specified closely the number of shovels of coal which should be fired at each interval. This idea proved very effective and for many years, and, in fact, until the introduction of oil fuel, not a battleship or cruiser went out for her trials without a "time firing" system on board, and many ingenious modifications in the signals were worked out. All of them, however, were based on the principle that the control of the signals, i. e., the time interval should be in the hands of one man who became solely responsible for the keeping up of the steam supply.

Time firing was found to be of such value in naval work that the signaling device was specified in the contract and made part of the standard equipment. It was also used successfully in large merchant vessels.

It is obvious that this time firing system, i. e., centralized control of hand firing of coal, had practically no bearing on labor saving. The same number of firemen were required as before. It did have the effect of producing plenty of steam and it did save fuel, but it cost the government or owner just as much for labor.

But if centralized control, in addition to its other advantages, results in marked saving in labor it becomes at once a factor in power development which cannot be ignored. It is in the use of oil as fuel that the full opportunity in this direction presents itself. Here the oil spray takes the place of the "coal heaver," and, if means may be developed for controlling the oil spray at one central point, then it is evident that the only labor required is that of supervising the sprayers or atomizers to make sure that each is operating properly and does not require cleaning or repair.

The great saving in labor which results merely from the use of oil alone has probably obscured the fact that additional labor saving is possible and that there are other economic advantages brought about by the introduction of centralized control.

Let us consider for a moment the method of operating an oil burning installation. If steam atomizers are used one fireman can look after 20 or 30 burners. He gives his attention to these individually, adjusts the oil valves and the steam spray and regulates the dampers to give the proper amount of air supply, and, as the load fluctuates, he makes the necessary changes to suit the conditions. The only trouble is that after a while he finds this work rather arduous and particularly when the load fluctuates rapidly he finds he cannot make the adjustments quickly enough. All the burners require changing at the same time, and he cannot get around fast enough to prevent smoking or excess air from entering the furnaces. Then he gets careless and gives up trying to have everything O.K. at all times, and he finds that, by giving all the burners an excess of steam and all the furnaces an excess of air, he can confine his labors to regulating the oil only. By this means he easily keeps the steam pressure on the plant where it should be, but the waste of steam through the burners and waste of heat up the chimney carries away thousands of good dollars that never come back.

If, on the other hand, mechanical atomizers are used, the waste of steam used for atomizing is at once prevented for the simple reason that none is used; regulation of this loss is taken out of the fireman's hands. But the ordinary type of mechanical atomizer is not sufficiently flexible to meet the requirements of a fluctuating load, so the burners have to be taken out and tips of various sizes substituted; or, what more frequently happens, some of the burners are extinguished and again ignited to meet the changing conditions and this means that the burners usually have to be disconnected and withdrawn from the furnace to prevent carbonizing when not in service. This requires more firemen.

This defect, however, in the mechanical burner has been met by the recent development of the Peabody-Fisher wide range mechanical atomizer which has a greatly increased range in capacity and is so arranged that any number of burners may be controlled simultaneously by the operation of a single valve on the by-pass oil return line.

With this burner centralized control becomes a simple problem.

LETTERS TO THE EDITOR

Angola, Indiana,
May 11, 1922.

The Blast Furnace and Steel Plant,
Pittsburgh, Pennsylvania,

Dear Sirs: I just received some news from Australia concerning Mr. J. W. Brophy that will interest a large number of your readers who are interested in the outcome of the proposed Queensland State Iron and Steel Works. Mr. Brophy was appointed general manager and erecting engineer of this proposition a couple of years ago; while he was chief mechanical engineer at the Broken Hill Proprietary Steel Works at Newcastle, N. S. W., Australia. Previous to holding this position he was chief mechanical engineer for the Tata Iron and Steel Company, Sakchi, Bengal, India. Mr. Brophy's early training was received in the Pittsburgh district where he still has many friends who will be glad to hear of his success in Australia. I shall give you an exact copy on it from "Truth" a well known Australian newspaper:

"Mr. J. W. Brophy, who has been appointed general superintendent of the Queensland State coal mines, is a typical product of American hustle. When an ambitious Labor Government saw the rapid advancement of Queensland through a bold iron and steel works program they found a man of enthusiasm for the job, and Mr. Brophy was the man. But the Government had not calculated on the financial overloads refusing to supply the sinews for the enterprise, and the man from "Amerka" who had been itching to show how they "guess" and "calculate" on such small jobs, was not utilized. The Government recognized that a good man standing by waiting orders is worth paying for standing by alone while the possibilities remain of the orders being eventually delivered. And that is why the Yank dynamo is being allowed to throb among the black diamonds. As the Minister of Mines aptly mentioned concerning the retaining appointment "fuel is fore-runner of iron and steel" and Mr. Brophy is its prophet."

Very truly yours,

Byron J. Brophy,
318 South Superior Street,
Angola, Indiana.

15th May, 1922.

Blast Furnace & Steel Plant,
Thaw Building,
Pittsburgh, Pa.

Attention Editorial Department.

Gentlemen: We have been interested by the article appearing on page 289 of your May issue, entitled "The Field of the Large Boiler" by Mr. J. B. Crane.

In the fifth paragraph, the author states:

> "If two to four boilers are considered sufficient to supply steam for a 5,000 or 10,000 kw turbine, it should not require more than this number of boilers for a 20,000 or 40,000 kw turbine, and when it is realized how much less apparatus there is to get out of order with a boiler and its auxiliaries than with a turbine and its accompanying apparatus, there must be something wrong with boiler designers if they fail to deliver the goods."

Certainly Mr. Crane is right in this statement, and we invite your attention to the installation at the Lakeside Plant of the Milwaukee Electric Railway and Light Company. Here, there are installed eight 1,306 horsepower Edge Moor Water Tube Boilers. These boilers are operated normally at 250 per cent of their rated capacity and at this output three boilers are sufficient to operate one 20,000 kw turbine, of which there are two in the plant. Two boilers are thus reserved as standbys and for future power requirements.

In a series of fifteen tests, the average efficiency of these boilers with their superheaters and economizers, proved to be 87.3 per cent. An efficiency of 85.6 per cent has been obtained from the boilers alone.

The above information is so apropos to Mr. Crane's article that we believe you may be interested in it.

Very truly yours,

C. R. Long,
McLain-Simpers Organization.

NEWS OF THE PLANTS

The Sizer Steel Corporation, Buffalo, N. Y., manufacturer of ingots, forged and rolled billets, steel bars, etc., has disposed of a bond issue of $1,250,000, the proceeds to be used for general extensions and additions in working capital. The company has recently acquired the plant of the Hammond Steel Company, Syracuse, N. Y., and will use a portion of the fund for this purchase. The rolling mills and other departments of the Hammond works, including 1-inch and 10-inch bar mills, will be placed in service at an early date. The property will be operated under the name of the purchasing company, and the Buffalo plant will maintain production as heretofore. C. B. Porter is president.

The Cleveland Cold Drawn Steel Company, 503 Leader-News Bldg., Cleveland, Ohio, has acquired property in the South Buffalo district, Buffalo, N. Y., as a site for the construction of a new plant. Preliminary plans are under way for the erection of a main one-story building and adjoining structures, estimated to cost in excess of $500,000, including machinery and operating equipment. C. H. Hopkins is secretary and treasurer.

Witherbee, Sherman & Company, 2 Rector Street, New York, N. Y., producer of iron ore, pig iron, etc., with blast furnace at Port Henry, N. Y., has preliminary plans under way for the construction of a new plant unit in the vicinity of the present works. The new blast furnace will have an initial output of 500 tons of pig iron per day, increasing the capacity of the plant to 150,000 tons of pig iron per annum. In connection with the expansion, a new sintering plant will be constructed, with a capacity of about 400 tons a day. The installation will also comprise a new pumping system with daily output of 9,000,000 gallons of water, two new boilers of large capacity; two new blowing engines with output of about 45,000 cubic feet, and other auxiliary machinery. A new laboratory, office, warehouse, and other structures will be built. To provide for the expansion the company is disposing of a bond issue of $4,000,000, about $2,000,000 of which will be used for the new plant. Lewis W. Francis is president.

The Somerville Iron Company, Chattanooga, Tenn., has completed plans and will soon commence the construction of an addition to its plant for increased production. Equipment will be installed to double approximately the present output, making a total capacity of about 3,000 tons of iron per day. The extension, including equipment, is estimated to cost about $65,000.

The Dowling Iron Works, Lincoln, Neb., has plans under way for the construction of an addition to its plant for increased production, comprising a one-story building, totaling about 2,500 square feet of floor space. Considerable new equipment will be installed. A. C. Koenig, Bankers Life Bldg., Lincoln, is engineer.

The Struthers Furnace Company, Youngstown, Ohio, is disposing of a hond issue of $1,500,000, a portion of the proceeds to be used for expansion, general operations, increase in working capital, etc. The company operates a blast furnace with capacity of about 15,000 tons of pig iron per month, average, and has recently completed a new power house, with pumping plant rated at 18,000,000 gallons per days. It is affiliated with the Cleveland-Cliffs Iron Company, in the ownership of the Wade and Helmer Mines in the Missabe Iron Range.

The Newton Steel Company, Youngstown, Ohio, manufacturer of steel sheets, etc., will soon take bids for the construction of a number of additions in its plant for increased production, estimated to cost in excess of $600,000, including equipment. The main feature of the work will consist of six new sheet mills and auxiliary operating departments.

The Duffin Iron Company, 4837 South Kedzie Avenue, Chicago, Ill., is planning for the construction of additions to its iron and steel works for increased production. A main two-story building will be erected, to cost about $25,000. John Duffin is president. Mundie & Jensen, 39 South LaSalle Street, Chicago, architects, are in charge of the work.

The Armstrong Steel Company, Fort Worth, Texas, recently organized with a capital of $2,500,000, has acquired the plant and business formerly operated under the name of the George W. Armstrong Steel Company. Preliminary plans are being prepared for the construction of a large addition to the present steel mills, for the production of general steel and iron products. At a later date it is proposed to construct a number of new mills for different character of production. A consideration of about $1,250,000 has been given for the property. Employment of 600 men, as heretofore, will be continued, and it is proposed to double this working force in the near future. George W. Armstrong, head of the acquired company, will occupy a similar position with the new organization.

The Wanner Malleable Iron Company, Hammond, Ind., has preliminary plans under way for the rebuilding of the portion of its plant recently destroyed by fire, with loss approximating $100,000, including equipment. The heaviest damage occurred in the soft rolling mill and the assembling works.

The Palmer Steel Company, Holyoke, Mass., recently organized with a capital of $100,000 to manufacture iron and steel products, including structural shapes, etc., has acquired a tract of about 14 acres of land at Meadow Street and McKinstry Avenue, as a site for its proposed new plant. The initial works will consist of a one-story building, about 70x200 feet, to be equipped for steel fabricating, and estimated to cost in excess of $50,000. At a later date, additional plant units will be constructed. Earl Palmer is president and Wayne F. Palmer, 7 Montgomery Avenue, Holyoke, treasurer.

The Riverdale Rolling Mill Company, 80 East Jackson Boulevard, Chicago, Ill., will commence the immediate erection of an addition to its plant at East One Hundred and Thirty-seventh Street and the Illinois Central Railway Tracks, Riverdale, near Chicago. It will be one-story, 65x140 feet, and is estimated to cost in excess of $40,000. The construction contract has been awarded to the Austin Company, 208 South LaSalle Street, Chicago.

The Darlington Iron Works, Darlington, S. C., is planning for the rebuilding of the portion of its plant recently destroyed by fire. Damage was sustained in a number of buildings, including equipment. The exact amount of loss has not been estimated.

The Vulcan Iron Works, Galveston, Texas, has plans under way for the construction of a number of additions to its plant for increased production, estimated to cost in excess of $75,000.

PRODUCTION TOPICS

THE PURCHASE OF REFRACTORIES*

By W. A. HULL, Chief, Refractories Section,
Bureau of Standards, Washington, D. C.

PART II

The activities of your Association have unquestionably had much to do with bringing the refractories manufacturers to a state of mind necessary to a whole hearted cooperation in a job like that. Association activities have a remarkable effect on the members of an association and on an industry. We have seen how it works out in other industries and it requires no supernatural vision to see how it is working out in yours.

One of the things that has been made evident by these conferences that have been held at the Bureau of Standards is that there is a wealth of information about refractories under cover. Perhaps it is too soon to expect it to come out; perhaps the Association is not ready to take the step; but if the cards could all be laid on the table, face up, it would go a long way toward straightening out the whole refractories situation.

What I mean is this: a steel company or a corporation which builds coke ovens makes tests and keeps records of performance and the results, except for certain general facts or conclusions are held as confidential information: the individual refractories manufacturers and the Refractories Manufacturers Association make tests and get, when they are able, records of performance, and the results are held as confidential; the Bureau of Standards makes a valuable investigation in which the properties of something like seventy brands of fire brick are determined and the results, so far as the names of the brands are concerned, are held as confidential. Think what a help it would be, in the writing of specifications and in the intelligent purchase of refractories, if all this information could come out in the open. I would hardly have the hardihood, at this time, to ask that such a course be followed. I realize that you manufacturers would hesitate to see your pet brands paraded for inspection, stripped of all the bunk and mystery with which your salesmen have kept them clothed and padded for decades: but I want to point out the alternative.

For a long time, we have been deceiving ourselves with the idea that the trouble with the refractories situation is that the user will not pay the price for the quality and the workmanship and the uniformity that he is demanding in refractories and that consequently, we cannot give them to him. Well, whose fault is it if he will not pay the price? Are most of the big users afflicted with some chronic sort of refractomania, which prevents them from following a sound policy in the purchase of this particular class of supplies? Are most of them so lacking in co-ordination between the purchase office and the production and accounting departments that they pay no attention to the effect of the quality of refractories on the cost of a ton of steel or whatever their product may be, or is it possible that they are doing the best they can with the information available?

Is the real trouble the lack of a market for really superior refractories, or difficulty in getting better prices for the common run of refractories. Suppose a purchasing agent does buy the cheapest one of a number of good brands of fire brick rather than the best. Perhaps it is poor economy to do that, but if so, why does he do it? Is it simply that the purchasing agent is unduly zealous in the matter of making a record or is it a part of a definite policy of his company? What might you or I do in his place? A number of brands of brick are available, any one of which is known to be suitable for a given purpose. There is a considerable difference in price between what we may term the aristocrats of the lot and some of the more lowly ones. No useful facts are available for the guidance of the purchasing agent in evaluating these brands except their general reputations and the records of the production departments; and it has been demonstrated that it is next to impossible to make accurate comparisons of the service of similar kinds of fire brick because of the irregularities and the accidental features of service conditions. What is the reasonable thing for the purchasing agent to do? Can you blame him very much if he solves his problem by driving as hard a bargain as he can and buying that one of a number of suitable brands which he can buy for the least money?

In taking advantage of low prices, a user faces the prospect that he may run into difficulties from variations in quality, from bad workmanship and various defects that he might not encounter to the same extent if he were to purchase from a company which maintains higher standards in these things as well as in price. This does not necessarily follow, however, and the user may feel that he can afford to take the chance, safe-guarding himself meanwhile by a rigid system of inspection and testing. Isn't this a fairly reasonable explanation of the procedure followed by some of the consumers and isn't it possible that they are getting away with it to the disadvantage of the refractories industry? Isn't it just possible that the whole industry is suffering from the effects of the secrecy about brands? If the manufacturer who is selling his product at a comparatively low price, had definite figures to show that his brand of brick is as good as he thinks it is—knows it is, possibly, then he might have the nerve to hold out for a decent price and get it. Henry Ford is credited with saying "Never lock up your engineering department—you may lock out more than you lock in." It seems worth while to consider whether manufacturers do not lose more than they gain when they keep some of their information confidential.

At the Bureau of Standards, we know from the inquiries that we receive, that consumers are eager for information about the qualities of different brands of brick. We do not give it to them because it is confidential information and to that extent we help to keep men in ignorance who are eager for facts. There are two things that in normal times keep the prices of refractories down—the law of supply and demand, and ignorance. Users refuse to pay a premium for superior quality simply because they have no way of knowing they are going to get it. They may not even know when they do get it.

Now the law of supply and demand is something difficult to overcome but the other factor can be controlled and if producers could overcome their inherent bashfulness about brands it would speed up the process of education amazingly.

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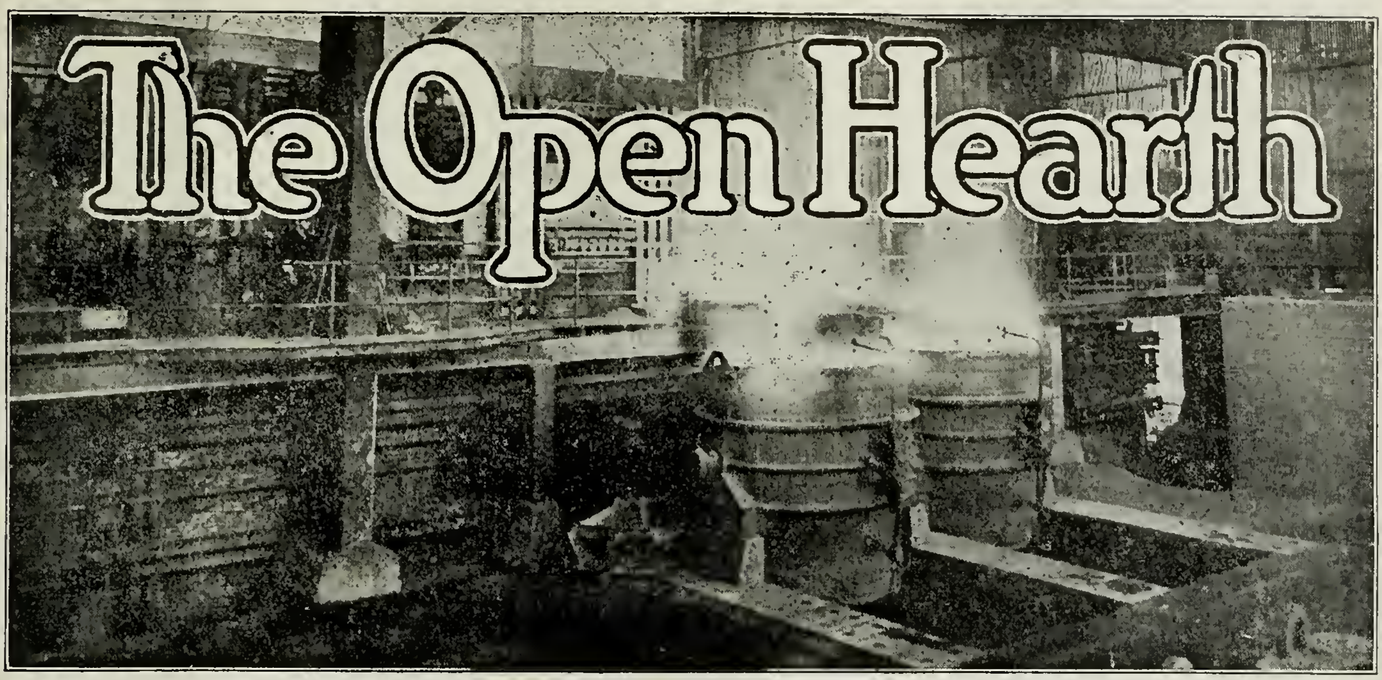
The Open Hearth



L. H. Miller, formerly connected with the Cleveland office of the Bethlehem Steel Company, has resigned to become managing director of the newly organized National Steel Fabricators' Association, the object of which is the establishment of standards for the guidance of steel fabricators with the view of bringing about uniformity in steel building construction and the conserving of steel used for this purpose.

R. M. Rice, purchasing agent, La Belle Iron Works, Steubenville, Ohio, recently resigned to go into business for himself in Wheeling, W. Va. His successor has not been announced.

C. J. Madjett, has been made general manager of the London Bridge Works, London, Ont. Mr. Madjett was formerly manager of the Standard Steel Construction Company, Welland, Ont.

J. T. Osler, who has been connected with the Hubbard Steel Foundry Company, East Chicago, Ind., in the capacity of manager of the roll department, was recently appointed general manager.

Charles J. Graham, who is vice president of the recently reorganized Graham Bolt & Nut Company, in which the Jones & Laughlin Steel Company now is largely interested, has been appointed special sales representative for the latter company.

Several changes were made in the personnel of the subsidiaries of the Wheeling Steel Corporation at a recent meeting of the board of directors. D. Allen Burt, who besides being vice president and treasurer of the Wheeling Steel Corporation has been president of LaBelle Iron Works, has become chairman of that company and is succeeded as president by A. J. McFarland, who a few months ago was made general manager of this company. W. W. Holloway has been made president of the Whitaker-Glessner Co. succeeding Andrew Glass, who has held that position besides that of vice president in charge of operations of the Wheeling Steel Corporation. George W. Moore, general manager, Portsmouth, Ohio, works, Whitaker-Glessner Company has been named vice president of the company.

John McConnell, vice president in charge of operations of the United Alloy Steel Corporation, Canton, Ohio, and Elton Hoyt of Cleveland, have been elected directors of the United Alloy Company succeeding J. A. Buell and E. L. Hang.

L. P. Ross was recently elected vice president in charge of operations of the Replogle Steel Company.

H. D. Scott, assistant superintendent Yorkville, Ohio. Works, Wheeling Steel Corporation, was recently promoted to the position of superintendent to fill the vacancy caused by the resignation of E. T. McNulty, who has become affiliated with the Charcoal Iron Products Co., Washington, Pa., as general manager.

R. E. Zimmerman, director of the research laboratory of the American Sheet & Tin Plate Company, Pittsburgh, has been appointed assistant to the president, effective May 1, succeeding the late Robert Skemp.

George Croak has been made general manager of Palmer Foundry & Machine Company, Palmer, Mass. Mr. Croak was formerly foundry superintendent of Athol Machine Company, Athol, Mass., and associated with the Becker Milling Machine Company, Hyde Park, Boston, previous to the former.

John N. Allen has been appointed purchasing agent, Donner Steel Company, Buffalo, succeeding E. L. Hendrickson. Mr. Allen, who resigned as manager of the mining and transportation department, Brier Hill Steel Company, Youngstown, Ohio, in 1919, to become vice president of the National Sales & Trading Company, Cleveland, was connected with the Lackawanna Steel Company for a number of years, prior to going to the Brier Hill Steel Company.

Charles J. Thompson was elected president and general manager of the Empire Tube & Steel Corporation, College Point, L. I., at a recent meeting of that company. Mr. Thompson for two years had been secretary and treasurer of that interest. L. J. Roine, who had served as assistant secretary, was elected treasurer, and J. J. Clegg, formerly auditor, was elected secretary.

James B. Tate has been made general purchasing agent for the Pressed Steel Car Company and its Chicago subsidiary. Mr. Tate had been acting purchasing agent for the past few months and is successor to J. H. Hackenburg, resigned.

William C. Bulmer has resigned, effective June 1, as superintendent of the open-hearth and Bessemer departments of the Carnegie Steel Company at the Ohio Works, Youngstown, a position he has filled for the past six years, to assume charge of a department of the Blaw-Knox Company, Pitts-

burgh, principally connected with water-cooling appliances for open-hearth furnaces and with the sale and installation of the McKune type of furnace.

Ledlie I. Laughlin, son of James B. Laughlin, former treasurer of the Jones & Laughlin Steel Company, Pittsburgh, who has been in the Pittsburgh office and mills of the company for several years, has joined the New York sales office. Mr. Laughlin is a director of the company and is seeking experience in all branches of the company's activities.

William Hutton Blauvelt has resigned his position with the Semet-Solvay Company, of Syracuse, N. Y., and has opened an office as Consulting Engineer, in the Equitable Building, 120 Broadway, New York City, where he will give special attention to the carbonization of fuels, and allied subjects. Mr. Blauvelt has been connected for many years with the Semet-Solvay and Solvay Process Companies, and has taken a prominent part in the development of the by-product coke industry in America. On account of his broad experience in the carbonization of coal, production of gas for domestic and industrial purposes, the recovery of by-products and the general utilization of fuels, he is a recognized authority on these subjects. The first important installation of by-product recovery gas producers, of the Mond type, was brought to this country and put into operation under his direction during the earlier years of his association with the Solvay companies.

Stewart M. Marshall of Perin, Marshall & Estep, consulting engineers, New York, has left India and is returning to the United States by way of England.

Harry Brown recently tendered his resignation as technical manager and as a director of the Bethlehem Shipbuilding Corporation, Ltd. Mr. Brown will leave for an extended vacation.

David B. Rushmore, Chief Engineer of the power and mining department of the General Electric Company has been appointed to the staff of consulting engineers of the company. His promotion is to enable him to devote his time more fully to general engineering problems. He is succeeded by K. A. Pauly.

Francis J. Hall, vice president of the Central Iron & Steel Company, Harrisburg, Pa., and connected with the company for the past 20 years, has resigned, effective May 31st.

Henry Marion Howe died at his home at Bedford Hills, New York, on Sunday, May 14th, 1922, from a malady which had confined him to his house for more than a year. Mr. Howe was born March 2nd, 1848, at Boston, Mass. His father was Dr. Samuel G. Howe famous for his service to Greece in her war for independence (from 1824 to 1830) and later for his labors in the instruction of the blind. His mother was Julia Ward Howe, author of The Battle Hymn of the Republic, and leader in many reforms. He was graduated in 1865 from the famous Boston Latin School, and four years later received his degree as Bachelor of Arts from Harvard College. Thus equipped, he entered the Massachusetts Institute of Technology, which gave him in 1871 the degree of "Graduate in the Department of Geology and Mining Engineering"—a cumbrous title for which the institution substituted, a few years later, that of "Bachelor of Science." And Harvard made him Master of Arts in 1872, and Doctor of Laws in 1905.

With the exception of approximately five years devoted to the metallurgy of copper, during which he inaugurated copper smelting in Chilt, designed and built the works of the Orford Nickel & Copper Company at Capelton and Tustis, in the Province of Quebec, Canada, and at Bergen Point, N. J., and managed the Pima Copper Mining & Smelting Company in Arizona, Dr. Howe's whole professional life had been devoted chiefly to the development of the iron and steel industry, as superintendent of steel works (Joliet, 1872, and Pittsburgh, 1873-4), consulting metallurgist, teacher of metallurgy, investigator, interpreter, writer and presiding officer. While acting as consulting metallurgist he was lecturer on metallurgy at the Massachusetts Institute of Technology from 1883-1897, professor of metallurgy at Columbia University, 1897,1913, and professor emeritus, 1913-1922.

Frank Gibbons, who has been in the general offices of the Central Steel Company, Massillon, Ohio, for a number of years, has been appointed sales manager for the Cleveland district of the company with offices at 904 Swetland Bldg., Cleveland.

Samuel M. Vauclain, president of the Baldwin Locomotive Works, and John C. Neale, vice president and general manager of sales of the Cambria Steel Company, have been re-elected directors of the Cambria company for a term of three years.

Some Pointers on By-Product Coke Oven Operations

PROGRESS IN BY-PRODUCT GAS UTILIZATION

By H. Dobrin*

For a brief consideration of our subject, and omitting the use of fuel in the blast furnace and boilers, let us start at the soaking pits, following on to the reheating furnaces, and through the fabricating divisions, to the remote corners where we find the blacksmith's forges.

The classes of fuel generally met with in the average steel plant are by-product gas, producer gas, oil, tar, coal and coke. The by-product gas from coke ovens does not always suffice for all the heating operations of the plant. Especially is this the case where a fabricating plant of small steel products is operated in conjunction with the blooming, structural or plate mills. Auxiliary plants of either producer gas, oil or powdered coal are therefore operated in conjunction with the available by-product gas.

The Soaking Pits.

Wherever by-product gas is available, its use for heating ingots for the blooming mill offers an ideal application. Where there is an occasional shortage, producer gas serves as a fine auxiliary. In some plants producer gas serves as the principal fuel, and by-product gas is used as an auxiliary.

That the latter gas is an ideal fuel for the soaking pit, is now an established fact in a good many steel plants. Time was, and for that matter still is, when all the ills incident to blooming mill operation were laid at the door of by-product gas used in the soaking pit. In the plants where its practicable and profitable use have been learned, one does not hear any more complaints of burnt steel or slow heating.

It is also well known that by-product gas is not as severe on the refractories of the soaking pit as is oil or producer gas.

Remember that, whatever producer gas or oil can do, by-product gas can do as well, in fact, better, and if there is any steel plant that has been unsuccessful in getting good results from the latter fuel, it is not the fault of the fuel by any means. A few small changes, either in the arrangement of the piping, or the taking out or the adding of a brick here and there, often constitute the difference between success and failure on this application.

Reheating Furnaces.

Coming to the reheating furnaces, we have now an even more suitable application for the by-product gas than at the soaking pit. If you have an auxiliary fuel for the soaking pits you should hardly require one for the reheating furnaces.

Here we may perhaps put our finger on one cause of high fuel costs—auxiliary fuel plants are often installed in too many departments. If you would analyze and definitely determine your fuel requirements, as well as your minimum available by-product gas supply, and then select the operations for which this gas is most ideally suited, and allot the gas to such operations, you would find it possible to dispense with a good number of auxiliary fuel installations. Give your fuel co-ordination the same care and attention that you give your power co-ordination.

The furnaces and operations for which the gas is best suited should then have the first call on the available supply. To avoid confusion, the gas could be pumped and delivered at a high pressure to the first-call units, and the other mills, not being so equipped, could not get the gas, except in periods when the supply is abundant, and would have to resort to their auxiliary fuel.

It is freely predicted by the writer that by-product gas will soon be the only fuel that steel mills will use in their reheating furnaces, providing this gas is at all available. This prediction is based on the success of a recent experiment in a steel plant where the checkers and stack of a reheating furnace were entirely eliminated, and the fuel cost, per ton of steel rolled, has for some months been consistently and steadily lower than the fuel cost on the old type regenerative checker furnaces. Nor has the fuel cost practice on this direct-fired, non-regenerative furnace been poorer than is tse average fuel cost practice in most mills. The heating quality of this furnace compares more favorably with the old-type furnaces both as to speed and uniformity, besides considerably reducing slag losses. As there is no underground work whatever on this furnace, you will readily see that the first cost does not begin to compare with the old type furnace. This furnace still has to be perfected along mechanical lines, but in view of the advantages that it seems to offer, it will not be long before it will be perfected.

Fabricating Mills.

Here is a part of the plant where there is room for improvement in almost every case. Especially is this true where the plant manufactures bolts, nuts, rivets, large and small forgings, and the multitude of other small steel products. The same applies to the plant which does a good deal of annealing, also welding.

In going through a forging or annealing shop, it is not uncommon to find the use of oil, tar, blacksmith's coal and coke, in addition to the by-product gas. And in order that the combustion of the above fuels may be facilitated, steam lines for the oil combustion, as well as a multitude of low pressure air blowers and high pressure air compressors for the gas combustion, have had to be installed. In addition we find the coal car siding for the dumping of the blacksmith's coal. Then the laborers required for wheeling the coal and ashes and cleaning the blacksmith's forges. It is now definitely established that by-product gas can displace all the above mentioned fuels, as well as the steam, low and high pressure blowers, coal and ash handling, and all the dust and smoke. A cleaner and speedier welding operation can be performed with gas than with either coal or coke, and, without fear of contradiction, at practically one-tenth the cost. It is all a matter of correct application of the gas, and a thorough control of the mixture of gas and air. This can be very well done, in view of the present stage of development of the art.

Now getting down to the general lay-out of a fuel conservation program, or rather a fuel cost-reducing program, it is well to bear in mind that the smaller the furnace the more ideal is the application of gas for it, and the more refined the operation or the product, the mort ideally is by-product gas suited for same. So, in laying out a plan, it is best to start with providing the smaller operations and furnaces with gas, and, of course, affording them first call on the gas. It is obviously simpler and cheaper to turn the auxiliary fuel on a row of soaking pits than to cause 40 or 50 small furnaces to go on an auxiliary fuel.

In a steel plant where all the furnaces in the fabricating division were converted to a single fuel—by-product gas—and where the use of oil and coal was entirely eliminated, thereby also dispensing with the need for steam, air compressors, low pressure air blowers and coal handling facilities, the resultant savings were a revelation, and exceeded by far the best expectations of the management.

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*Consulting Fuel Engineer, Birmingham, Ala.

TRADE NOTES

The American Industrial Engineering Company, Chicago, has recently taken an order from the Tennessee Coal, Iron and Railroad Company for the installation of complete low pressure pulverized coal burning plant for utilizing pulverized coal as fuel under one of the boilers in that company's new power plant at Ensley, Alabama.

The Gas Combustion Company of Pittsburgh, Pennsylvania, has recently filled its fourth repeat order for Bradshaw Burners at Carnegie Steel Company, New Castle Plant, New Castle, Pennsylvania. They have also received an order to equip the new boiler plant of The Tennessee Coal, Iron and Railroad Company at Ensley, Alabama with the Pressure Type Bradshaw Burner.

Metal & Thermit Corporation, New York, announces the removal of its Pittsburgh Branch Office from 1427 Western avenue, to 801-807 Hillsboro street, Corliss Station, Pittsburgh, Pa.

The Atmospheric Nitrogen Corporation has ordered from The U. G. I. Contracting Co., of Philadelphia, additional equipment for its blue gas plant at Syracuse, N. Y.

The La Belle Iron Works of the Wheeling Steel Corp., Steubenville, Ohio, have taken definite action to greatly increase both efficiency and production of the open hearth furnaces at their plant. One of the furnaces has been rebuilt after the McKune plan and sixteen additional Chapman Floating Agitators with automatic feed are being installed. These sixteen are in addition to four already in service, thus equipping a large portion of the gas producers supplying the furnaces. Previously each furnace was supplied by four 8 ft. inside diameter hand-poked producers. As a result there was usually a shortage of gas. Now three producers equipped with agitators easily take care of each furnace, giving a uniform supply of high grade gas so essential to secure better furnace operation and increased production.

The U. G. I. Contracting Co., of Philadelphia, has received a contract from the Northern Indiana Gas & Electric Co. for the installation of 15 ft. circular steel purifiers to be installed at Michigan City, Ind.

The American Supply Company, 135 Washington St., Providence, R. I., has been appointed agent for the Providence district to represent the Quigley Furnace Specialties Company of New York, manufacturers of HYTEMPITE. The Quigley products are warehoused in Providence for quick delivery to local points.

The Electric Furnace Construction Co., Philadelphia, advise that the Electric Steam Generator of the "Kaelin System" recently installed at the Laurentide Paper Co., commenced operating April 21st. Although only designed for 25,000 kilowatts, this boiler is averaging 34,000 kilowatts and is producing 100,000 lbs. of steam per hour at 125 lb. pressure.

The Western United Gas & Electric Co. has awarded contract to The U. G. I. Contracting Co., of Philadelphia, for the installation of one (1) 11 ft. cone top set of Carburetted Water Gas Apparatus and two (2) Waste Heat Boilers to be installed at the Joilet, Ill. plant. Included in the water gas installation will be one (1) U. G. I. Automatic Control.

The Taylor-Wilson Manufacturing Company, McKees Rocks, Pa., has recently opened a Sales Office at 1212 Park Bldg., Pittsburgh, Pa. This office is in charge of Mr. Wm. Y. Banks, Jr., as Special Sales Manager.

The Sharon Pressed Steel Company on May 1st will move their office from No. 66 Broadway to their new warehouse in the Dodge Building at No. 47 West Broadway, corner of Murray street, where they will carry for demonstration a complete line of trucks, trailers, skids and other pressed steel products.

TRADE PUBLICATIONS

Adam Hilger, Limited, Optical Works, 75 A Camden Road, London, N. W. 1, have issued a very interesting pamphlet descriptive of their chemical spectrometer It contains information also regarding the use of this instrument.

W. S. Rockwell have issued Bulletin No. 242. "The Influence of Method of Heating and Handling on Quality and Cost of Heat-Treated Products," summarized in this Bulletin, should interest those concerned with the problem of producing better products at less cost, because of reference to essential factors generally overlooked in practice and illustrations of the practical application of the principles outlined.

The Scientific Materials Company have issued a pamphlet describing "The F and F Optical Pyrometer." This instrument is used to measure the temperatures in Fuel Beds, Heat Treating Furnaces, Coke Ovens, Open Hearth Furnaces, Soaking Pits and other locations where high temperatures are obtained.

Paul Haehler Co., Chicago, Ill., has issued a new catalog which describes in detail its line of industrial ovens. The construction of Maehler ovens is given, as well as data on ventilation and circulation, assembling or setting up, fuels for industrial ovens, gas-heated ovens, electric heat and its adaptation to Maehler ovens, conveyor and special type ovens, core ovens, potash tanks and boiling cauldrons and oven accessory equipment. The booklet is well illustrated.

The Page Steel & Wire Co., Monessen, Pa., has just issued a new handbook describing and illustrating interesting developments in the welding field.

The Aeroil Burner Co., Inc., Union Hill, N. J., has just received from the press its new bulletin, No. 20, on "Oil-Burning Appliances."

Clement K. Quinn & Co., Duluth, Minn., has issued its 1922 Analyses of Lake Superior Iron Ores.

The Grindle Fuel Equipment Co., Harvey, Ill., has issued its first general catalog on Grindle powdered fuel equipment, which contains 40 pages of text and illustrations. The advantages of powdered fuel in general is given and the advantages and operation of the Grindle system in particular. Copies will be sent to interested parties on request.

The Chapman-Stein Furnace Co., Mt. Vernon, O., is circulating four separate bulletins on industrial furnaces under one cover. These furnaces are of the recuperative type, in which the air and usually the gas, are both preheated by passing through chambers previously heated by the spent gases. The furnace applications described in the bulletins include rolling mill use, forging and annealing. The data given are complete and very interesting.

The Peabody Engineering Corp, New York, has published an 8-page illustrated bulletin in which a mechanical atomizer and air register is described. This air register is designed to give absolute control of the air supply under varying load conditions. The shutters are so arranged that they give the air current the correct amount of rotation for all loads, and the register is so constructed that all the shutters may be placed in the position to give the right amount of air for perfect combustion by turning a handle.

The R. J. Teetor Co., Muskegon, Mich., is circulating an illustrated folder in which attention is called to its line of molding machines. Three models are described.

The Independent Pneumatic Tool Co., Chicago, has published a small folder in which pneumatic drills for light work, drilling, reaming, wood boring, screw driving, cleaning, polishing, removing scale, paint or rust are described and illustrated.

The Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., is circulating a 4-page illustrated bulletin in which an electric hoist is described and illustrated. It is claimed this hoist has a wide range of application. Details of construction are given in the folder.

The Blast Furnace and Steel Plant

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Control of Silicon in the Blast Furnace

Discussion Showing How the Composition of the Iron Is Regulated by Varying in General the Composition of the Charge and by Controlling the Temperature of the Hearth.

By S. L. GOODALE
Professor of Metallurgy, School of Mines, University of Pittsburgh

PART II

THE proper control of silicon is one of the most important factors in the management of quality of cast iron during the processes of manufacture. A great deal of study has been put on this subject over a period of many years. Most of this study has been carried on by plant investigators using the facilities of the various foundries with which they were connected, and securing, primarily, results of direct application to the solution of their own particular problems, and often of little further value. Most of the results of such studies have never been published at all, and when published are usually very difficult to compare because of the different conditions in the various places where the work had been done. Nevertheless, so much of careful comparison of results has been done that most of the various influences are now much better understood than formerly.

The influence of silicon for the most part is well understood in a practical general way, and the scientific explanation of its influence has been pretty well worked out. The equilibrium diagram of the iron silicon alloys was very carefully determined by Messrs. Guertler and Tamman some years ago, and Gontermann worked extensively and painstakingly on the diagram of the iron-carbon-silicon system.

Guertler and Tamman concluded, as a result of their own work and that of previous investigators, that silicon, up to some 18 per cent by weight, exists in iron as a compound of the composition Fe_2Si in solid solution in the iron. Commercial cast iron does not go over 4 or 5 per cent of silicon, usually much lower than that, and this part of the equilibrium diagram is sufficient for our present purpose. This investigation, of course, refers to the properties of pure iron-silicon alloys, and not directly and primarily to the influence of silicon on commercial cast iron. But in order to understand the effects of silicon on cast iron it will certainly be of use to know the kind of alloy that pure iron and pure silicon will make without other elements being present.

The very nearly pure iron silicon alloys are used for electrical purposes where high magnetic permeability and low hysteresis are desired and where high electric resistance is also useful. Such material is made into thin sheets and then punched to the shapes needed for making the cores of transformers and armatures for dynamos and motors. Transformer core metal may contain up to 4.25 per cent of silicon, usually running about 4 per cent, and becoming rather brittle if it goes much above these limits, and the sheet for dynamo and motor core use contains usually about 1 per cent silicon in order to secure freedom from this brittleness, and because this sheet has often to have great physical strength and reliability. Power losses are cut down in two ways by using silicon steels for these purposes. The direct magnetic losses are lessened by the lower magnetic reluctance of the metal, and the stray current losses which cause heating of the cores are lessened by the high electrical resistance. In these cases it is the direct influence of the silicon on the iron that is of importance.

In commercial cast iron the effect of silicon on the condition of the carbon is of greater importance than its direct effect on the quality of the metal. In studying this subject it is necessary to realize that silicon does have at least two kinds of effects, which may or may not be independent of each other. It has firstly a direct influence when added to pure iron, as described in the paragraph above, and secondly it has the effect of a precipitant on carbon. Silicon, also, has an extremely high heat of oxidation, and because of this it is used in both iron and steel to act as a scavenger to remove oxygen and so assist in securing sound castings, but this use of silicon does not require much more silicon to be used than will be oxidized; and there is thus practically no silicon, or but very little indeed, really left in the metal because of this use. It is the second effect above mentioned that is most important to the iron foundry man, and with which this paper will mainly deal.

Commercial cast iron is a very complex alloy of some six principal elements, and a varying number of others, the importance of some of which at times is very considerable. Presumably each one of the elements entering into the composition of any cast iron has some effect or effects on the properties of that iron. And although cast iron has been known and carefully studied for so many years these effects are not yet fully known for even the five principal alloying elements added to the iron in the metal. The reason for this is the great complexity of the subject, and the fact that there are usually other factors affecting the matter than the composition only as determined. This brings us to a question about which much controversy has raged, and that is, can one tell what the properties of a given pig iron will be from its analysis?

Can one tell the properties of pig iron from its analysis? Yes and no. Ideally, yes; practically and theoretically, no. An ideal analysis would be a complete analysis—it would tell us just how much of everything the metal contains. Actually, such analyses cannot be obtained. It is very difficult to get representative samples, and it would cost too much to determine the exact amounts of some elements that are present in amounts of a few hundredths of one per cent. Cast iron may contain a few hundredths per cent of such elements as copper, nickel, cobalt, or even silver or gold, and possibly also of oxygen, nitrogen or others. Presumably, the effects of the traces of these elements can for the most part be neglected, but we cannot be sure about this for any particular element until it has been investigated by competent workers. We certainly cannot predict the properties of an alloy from its analysis unless we have a complete analysis, or know the analysis to be sufficiently complete to permit of its determining all the properties desired to be known. Analyses, as usually made, even those called complete analyses, are not ideally complete. Therefore we certainly cannot predict the properties of pig iron from the analyses usually available.

From time to time circumstances arise which cause one or another of these details to be investigated carefully, and it is known that the effects of very small amounts of many of the elements, such as copper and nickel, etc., are so slight as to be negligible for practical purposes. While many of these are negligible, it is by no means sure that all of them are. In fact, within a few years a very good case has been made out tending to prove that the effects of a few hundredths of a per cent of oxygen is of very great importance in determining the properties of cast iron. The late J. E. Johnson, Jr., did a great deal of careful work on this and reported his results in a very convincing manner. It is hard to understand how it is possible for oxygen to exist at a high temperature in composition in an alloy that contains so many elements that ordinarily combine energetically with oxygen. The exact form of the oxygen was not determined in Johnson's research, neither was the effect quantitatively determined. It was found that iron with any small per cent of oxygen within limits would have certain valuable properties, and iron otherwise, as far as determined, identically alike, but having no oxygen, did not have those properties and was not so good.

When a small amount, up to 18 per cent by weight, of silicon alloys with pure iron the compound Fe_2Si is formed, and this compound then exists in solid solution in the alloy. The properties of this solid solution alloy of iron and silicon are somewhat different from the properties of pure iron. The electrical resistance and magnetic permeability are increased, the magnetic reluctivity decreased, and the crystallization of the metal is made coarser. The alloy is not able to dissolve as much carbon as can the pure iron. The alloy is much more resistant to the ordinary acids than is pure iron, and this property is made use of in a number of special acid resisting casting compositions high in silicon which have been developed. These castings are usually very hard and very brittle. But a factor that has a certain action on pure iron may or may not have just the same action on iron when some other element is present; and each added element complicates the situation in the number of possible actions it may exert in view of varying composition.

For irons as used in ordinary gray iron, or in malleable, foundry work, the more important effect of silicon is its influence on the condition of the carbon. Carbon may be present in cast iron either as graphite, or as the compound Fe_3C. Graphite is a soft, black substance with a strong tendency to crystallize in leaves or plates when conditions permit. It is itself weak and non-adherent to iron, and it therefore affects the strength of the metal according to how much it breaks up the continuity, and this depends on the shape, arrangement and size of the particles of graphite. And the shape and size of graphite particles can vary very widely from globular particles of a diameter less than a hundredth of an inch, to plates an inch or more in extent, along which the metal cleaves with little effort. Any influence which tends to control the shape and size of graphite particles will be of great importance to foundry men, and this is what J. E. Johnson, Jr., claimed for oxygen, namely, that the presence of a small amount of oxygen caused the graphite to be present in small, scattered particles which break up the continuity of the iron much less than the coarse plates formed in the ordinary run of foundry gray iron. He stated even that the presence or absence of silicon, phosphorus and manganese will not account for half of the facts which have long been known concerning the control of the carbon condition, fluidity and chilling qualities of the iron.

Silicon has a strong effect which varies with temperature and the amount of silicon present, tending to force carbon into the form of graphite, this tendency being stronger the higher the temperature. The tendency is so slight at temperatures below the pearlite transformation point that it is not usually effective except in the presence of a catalyzing agent, such as graphite already formed at a high temperature. In the case of iron alloys rich in carbon, i. e., cast irons, silicon seems to act to lessen the total amount of carbon the metal is capable of absorbing. According to Hatfield some 3.25 per cent of silicon will reduce the carbon in iron from about 4.3 per cent to about 3.4 per cent, and 25 per cent of silicon further reduces the carbon to about 1 per cent. The presence of the silicon raises the freezing point of the eutectic from about 1135 deg. C. for pure iron to 1190 deg. C. for the 3.25 per cent silicon alloy and to some 1250 for the 25 per cent alloy. In spite of the higher melting point of the silicon containing alloys they are very fluid when melted, and this effect is one of the practical points in the use of silicon in commercial amounts.

It is not known that the silicon has any particular effect to control the shape of the graphite; it merely tends to change the carbon from the form of the compound Fe_3C to the form graphite. The thing that mainly controls the shape of the resulting graphite is the temperature at which the change has been forced in any particular case, and it may be that oxygen also has a very important influence on these factors, though the way in which this influence is exerted is not yet exactly known.

But the control of carbon as between graphite and combined carbon does not tell the whole story. As Fe_3C. carbon may exist in iron in different ways, and the treatments under which silicon is active are also treatments which affect the Fe_3C, entirely aside from the way it is affected by the silicon present. The combined carbon may exist in iron as a part of the constituent called pearlite which is composed of very minute alternating leaves or plates of iron and of this compound Fe_3C; and it may also exist as a separate constituent by itself in a more or less massive crystalline form, when it is often spoken of as free cementite. On heating iron past a temperature of about 700 deg. C. the pearlite undergoes a change, and its constituents, iron and carbide, merge or dissolve in one another and form a new constituent, called Austenite, which is the normal form of the alloy at high temperatures. The iron in this solid solution is in a different condition from the iron in the pearlite, a different allotropic modification with different crystal form and different other properties. As the temperature rises above 700 deg. C. to about 1130 deg. C. this Austenite is capable of dissolving increasing amounts of carbon as Fe_3C up to about 1.7 per cent of carbon at 1130 deg. C. If more carbon is present at any temperature than the Austenite can dissolve it is probable that it is this excess carbon not in solid solution that is first affected by the silicon present at the high temperature and caused to break down from the compound form into graphite. Furthermore, there is the possibility that the carbide that exists in solid solution in the Austenite may be, to a certain extent, dissociated into ions, or some similar form, in a manner analogous to electrolytes in water solution, and that the carbon containing ion may be more susceptible to the action of silicon than the carbon of the carbide in solid solution and not dissociated. Since in some cases all of the carbon in cast iron exists as graphite it is quite possible that the silicon can force the change also of the carbon that is dissolved in the Austenite, although the last portions of the carbide to be broken down may be changed at a temperature below the pearlite transformation.

If, at a very high temperature, in the solidification of a molten iron, carbide be crystallized out, the tendency of any silicon present to change this into graphite and iron is very strong. Grey iron is formed when the tendency is just strong enough to cause the graphite to form while the iron is in a plastic, but not fluid condition. Graphite that forms while the iron is still thoroughly fluid will naturally rise to the surface and float away as kish, although often some of the kish is caught near the surface in the iron in masses. Since in gray iron the graphite exists for the most part in idiomorphic crystals, well scattered through the metal, the condition of the metal when they formed is thus fairly definitely established. If the graphite is formed after the iron has completely solidified it must come out in the forms that are characteristic of malleable castings, rather than the idiomorphic leaves, etc., in which it occurs in gray iron.

It was stated that in pure silicon alloys the silicon exists as the compound Fe_2Si in solid solution in the iron. But cast iron is a complex alloy and we need to consider not the iron and silicon alone, but also carbon, manganese, sulphur and phosphorus also, and how these added elements affect the alloys. When carbon only is present in addition to silicon and iron, the carbon exists as above outlined, and the silicon exists mainly in the ferrite or pure iron part of the alloy in solid solution, while a smaller portion of the silicon is crystallized with the carbide Fe_3C, and it is quite likely that it is the small amount of silicon so crystallized that lessens the stability of the carbide so much.

Professor Albert Sauveur, of Harvard University, has very ably presented the idea of the importance of the proximate composition of alloys, especially iron and steel. The term proximate composition or proximate analysis must not be confused with the similar sounding word approximate. Proximate analysis means analyzing into the physically separate entities or smallest particles we can distinguish by purely physical means which go to make up the alloy. These entities have been named by Professor Howe "metarals." Cast iron is made up of the metarals, ferrite, pearlite, cementite or free cementite, graphite, sulphides, Steadite or the iron phosphide eutectic, and others according to its ultimate composition. Each metaral may be an element, or a compound, or possibly a mechanical mixture such as an eutectoid alloy. The metarals are the separate things seen when the sample is properly prepared and examined by the aid of the microscope, and occasionally some of the metarals may be large enough to be seen without the microscope, though this would be doubtful in any good commercial metal.

Manganese forms solid solution alloys in all proportions with iron. It also forms a carbide of the formula Mn_3C, which is capable of crystallizing with Fe_3C, and in any irons containing much manganese it is probable that a part of the manganese exists in both of these forms. Manganese has a much higher affinity for sulphur than has iron, and whenever something like twice or more than twice as much manganese as sulphur is present most of the sulphur will form either manganese sulphide or complex manganese iron sulphides.

Sulphur forms with iron the compound FeS, which is fairly stable at high temperatures. This sulphide is very detrimental to iron because it forms envelopes about the iron grains, and having itself little strength mechanically and but little cementing quality, it makes what is called a rotten alloy, or one which will crumble easily. This effect is particularly in evidence at a fairly high temperature, about in the rolling temperature for steel, when the iron sulphide is melted or plastic. The manganese sulphide or manganese iron sulphides that form in preference to iron sulphide when sufficient manganese is present behave very differently in iron, partly because of their higher melting point and partly because of the different surface tension between them and iron. The shape of the particles of the manganese bearing sulphides tends to be more bulky than the pure iron sulphide, so the manganese bearing sulphides appear as small round globules, or as these globules may be elongated into strings, not as the extended envelopes that enclose the grains of the metal. Aside from this effect of sulphur, sulphur has a very powerful influence tending to make the carbon remain in the combined form; and in this way sulphur strongly opposes the action of silicon. It may be that it exerts this influence by a part of it being crystallized with the carbon in the carbide and making this compound Fe_3C more stable. It may be even that it combines with some of the silicon that is so crystallized into a compound of sulphur and silicon and so directly neutralizes the effect of the silicon.

Hatfield investigated the influence of sulphur, manganese and silicon upon the precipitation of graphite, and reported that the silicon is present to a certain extent in the carbide, but mostly in the matrix; the manganese is largely found in the carbide to the exclusion of silicon, and the sulphur also appears to cause the exclusion of the silicon from the carbide, though the methods employed failed to find any sulphur in the carbide. Their heat treatment experiments indicate that the presence of these elements modifying the composition of the carbide renders it more or less difficult to dissociate at a given temperature, and altering the composition of the alloy renders it more or less soluble in the Austenite, thus changing the amount of free carbide to be acted on by any influence. It seems that both manganese and sulphur, each separately, tend to make the carbide more stable, but that to a certain extent they may each neutralize the effect of the other in this direction.

Phosphorus forms the compound Fe_3P, and this alloys with iron, going into solid solution therein with limits, or with iron and carbon forming an eutectic of very fluid character and low melting point, and which may be used when very fluid irons are required that do not need to have great strength. These iron, carbon phosphorus alloys are very interesting. Carbon and phosphorus tend mutually to exclude each other from iron, or each to lessen the amount of the other than the iron can take up. Phosphorus is used in cast iron to a notable extent only in cases where a very fluid iron is needed in order to flow some distance in a thin sheet through a mold, or when an iron is needed which will expand at the moment of solidification and so fill the mold with great exactness even in its finest detail as in some art castings. This iron with high phosphorus is very brittle, but is still strong enough for many uses.

The effect of silicon can be explained by explaining its effect on the proximate composition of the cast iron. To do this let us first make a rough statement of what the metarals in cast iron are. We may begin with the manganese and phosphorus. Some manganese first unites with all of the sulphur present to form MnS, or with some iron and all of the sulphur to form mixtures of MnS and FeS. What manganese is left over from this is divided, part of it forming Mn_3C and crystallizing with the Fe_3C and the rest going into solid solution in the ferrite. The phosphorus forms Fe_3P and this forms with ferrite an eutectic alloy; in cast iron but very little phosphorus remains in solid solution in the ferrite. The carbon is present as pearlite, or pearlite and cementite, and graphite, according to the total carbon, and the silicon and heat treatment to which the metal has been subjected. The effect of the silicon both in the ferrite and in the cementite has been outlined above.

Moldenke and West and others have made experiments to determine the relative melting temperature of white and of gray iron, and showed that the white iron melts at a lower temperature than the gray, and melts in about the same fashion as ice, whereas gray iron goes through a mushy stage in melting. Irons with high combined carbon were found to melt at about 1100 deg. C., while those with but little combined carbon and mostly graphite melted at about 1230 deg. C. Grey iron melted at about 110 deg. C. lower temperature than steel with the same amount of combined carbon. These facts are of obvious interest in regard to the arrangement of charging iron of various kinds in a cupola furnace.

The shrinkage of cast iron is the contraction of the liquid iron in cooling from the pouring temperature to the setting point, together with any contraction that may occur in actual setting or freezing. In other words, it is the amount that would have to be added of liquid iron to secure a thoroughly sound casting after the mold is first just filled. The difference in size between pattern and finished casting is properly termed contraction. Most of the difference between different irons in regard to this contraction from pattern to cold casting seems to correspond to the distribution of carbon as between the combined and graphitic forms. When all or nearly all of the carbon is in the graphitic form the contraction amounts to about ⅛ in. to linear foot; when all the carbon is combined, to about ¼ in. to the foot. It is reasonable to suppose, therefore, that the volume occupied by the carbon as graphite is about the equivalent of ⅛ in. to the foot. In actual volume this works out about as follows: a pattern containing 100 cu. in. will yield a gray iron casting containing very nearly 97 cu. in., or a white iron casting of 94 cu. in. The white iron casting on being well annealed will expand again to 97 cu. in.

As silicon is one of the chief agencies by which the condition of the carbon may be controlled, it will be seen that the relationship between silicon and shrinkage and contraction are very close. The quantities of manganese and sulphur are also very important. It is interesting to note that in the formation of graphite the increase of bulk must take place against the resistance of the metal, and that the metal is actually expanded by an amount corresponding to the increase. Each spot of graphite has had to open up space enough for itself by stretching the iron surrounding it; and it is probable that this pressure is one of the large factors in control of carbon condition in castings. The actual working of the metal matrix thus caused is very slight, and takes place at a high enough temperature so that its effect is overcome by self annealing.

PITTSBURGH TO ENTERTAIN CHEMICAL SOCIETY

Pittsburgh will be the host of the American Chemical Society at its Annual Fall meeting, from September 4th to September 9th, inclusive. All of the divisional meetings will be held at the Carnegie Institute of Technology, while the general meetings are scheduled at Carnegie Music Hall.

An exceptional program has been outlined for the entire week, with a variety of social events for the Councillors and their wives.

Of outstanding importance in the program will be an address by Thomas Midgley, Jr., of the General Motors Research Corporation on "Chemical Control of Gaseous Detonation with Particular Reference to the Internal Combustion Engine." Mr. Midgley will be assisted by T. A. Boyd. The lecture will include demonstrations of normal combustion and detonation in glass tubes, the suppression of detonation by the addition of certain chemical compounds, and demonstrations with an internal combustion engine motor containing quartz windows and apparatus for measuring radiation. The motor will be operated on detonating and non-detonating fuels. Lantern slides will be shown illustrating the periodic variation of anti-knock value among the 16 elements. Blueprints of the paper will be issued at the meeting.

"Pittsburgh as a Chemical Manufacturing Center" is the subject of an address to be given by Dr. J. H. James, Head of the Department of Commercial Engineering, and Dr. W. F. Rittman, Head of the Department of Commercial Engineering, of Carnegie Institute of Technology. Dr. James will discuss "Pittsburghs' Raw Materials and Markets for Chemical Products." Dr. Rittman will speak on "Pittsburghs' Transportation and Financial Advantages."

By special arrangements, the Committee of the Pittsburgh Section of the A. C. S. has obtained dormitory privileges for the Councillors at Carnegie Tech during the Meeting. The Men's Dormitories will be opened to house 350. One of the Women's Dormitories has been offered for the use of Councillor's wives.

Heat Transmission in the Hot-Galvanizing Process

Describing the Thermal Features of the Process—The Rate of Motion of the Sheets Through the Bath Should Vary With the Sheet Thickness If Based on the Factor of Heat Transmission.

By J. D. KELLER

ALTHOUGH the hot galvanizing of iron and steel sheets is an old and well-known process, very little study seems to have been given to the conditions of heat transmission occurring in it. The rates at which sheets of various thicknesses should be passed through the zinc bath have had to be determined simply by trial and re-trial, the controlling factors being little understood. In the present article an attempt will be made to make clear the thermal features of the process, and to see how, if based on the important factor of heat transmission, the rate of motion of the sheets through the bath should vary with the sheet thickness.

And first it will be well to consider the mechanical or physical actions occurring in the galvanizing bath. Referring to the diagrammatic sketch, Fig. 1, the steel sheet, fresh and clean from the pickling process, passes through the first pair of rolls, and through the flux box at (A), enters the molten zinc at (B), passes through the bath to the submerged rolls at (C) and thence is directed by the guides to the third set of rolls at (D). By them it is drawn out and sent on to the conveyor. Heat must not be imparted to the bath from the bottom of the pot, because the dross and lead would thereby be stirred up and would contaminate the zinc. Fire spaces are provided at the ends of the pot, and sometimes also at the sides.

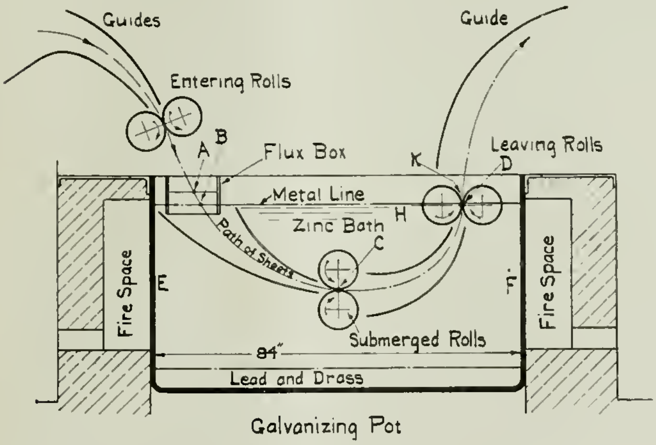

Fig. 1—Diagrammatic sketch of galvanizing machine.

It is very important to note that the bath is continually and quite violently agitated by the motion of the rollers, and of the gears and mechanism which drive them. This is made evident by the "wash" or churning up of the bath, near (B) in particular. The agitation produces most excellent heat transmission through the molten zinc (by means of convection currents), and carries the heat from (E) and (F) to the sheets with very little drop in temperature. It also provides for thorough mixing of the different portions of the molten metal. The zinc at (H) receives no heat during the time in which a sheet is passing between it and surfaces (E) or (F), but during the intervals between passages of the separate sheets, its supply of heat is replenished by mixing with zinc from other parts of the bath.

At some point in the passage of the sheet, the rising temperature of its surface reaches the fusion temperature of zinc, and the formation of the zinc-iron alloy, which cements the zinc coating to the sheet, can then begin.*

From the theory of heat conduction it is known that when two substances are in very perfect contact, no "temperature drop" should occur across the contact surface. Careful temperature measurements at such contacts—for instance, the contact of polished flat metal surfaces, or that of a liquid or plastic material with a solid,—have shown that in fact no temperature drop exists there. Where a temperature drop appears to exist, this in reality means a steep temperature gradient in a layer or film of some substance, such as air, which has a high resistance to the flow of heat.

This naturally brings up the question, how can the liquid zinc come in contact with the cold steel surface and still remain molten? The answer is that it does not do so; an infinitesimally thin film of solid zinc forms instantly on the surface of the sheet; the film thickens, at first very quickly, then more and more slowly. Finally it reaches a maximum thickness, then starts to melt off. The melting progresses with increasing rapidity until the solid film entirely disappears, and the liquid zinc comes in contact with the steel surface.

As shown in the diagram of Fig. 2 (in which thicknesses are much exaggerated), there is, first, the steel sheet itself (1); then a layer of solid zinc (2), varying in thickness as time goes on; next a layer or film of more or less stagnant liquid zinc (3); and beyond this the main body (4) of the zinc bath, in violent agitation.

Just here it must be remarked that between (1) and (2) there may possibly exist a slight film of flux; but in any case this would be so thin that the heat transmission would be very little affected. Also, it should be mentioned that when the sheet enters at (A), Fig. 1, there is a thin film of water adhering to its sides. Any part of this water which is not absorbed by the flux between (A) and (B) will be evaporated shortly after entering the zinc bath.

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*It is stated that the zinc powder which is used in the dry galvanizing or Sherardizing process begins alloying with the steel or iron surface at a temperature 200. deg. lower than the melting point of zinc. On the other hand, it is stated that the fusion point of the zinc-iron alloy formed in hot galvanized coatings is noticeably higher than that of pure zinc. In any case, the alloying during hot galvanizing would not begin until the film of solid zinc, referred to further on, had disappeared.

The film (3) of Fig. 2 is not to be considered as a sharply defined layer. As the steel sheet with its adhering layer of solid zinc passes rapidly through the bath, it drags some of the liquid along with it. Thus the particles near surface (5) have very little motion relative to the sheet. From (5) to (6) the relative speed of motion rapidly increases. Rate of heat transmission is greatly influenced by the rapidity of this relative motion.

Permissible Speed of Travel of Sheets Through Bath.

As will be shown in the second part of this article, the heat distribution in thin sheets is so nearly uniform throughout, at the instant when the solid zinc has just disappeared, that the center can never be as much as one-half degree below the surface temperature; probably it will be only a few tenths degree below it.

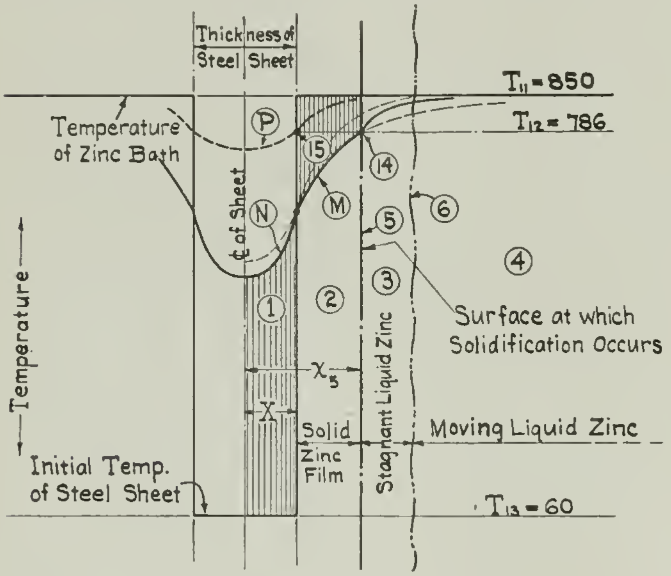

Fig. 2—Conditions during galvanizing.

This conclusion makes the calculation of heating time a very simple matter. Taking the temperature of the sheet as constant throughout would mean an error of less than 1/20 per cent. The heat absorbed by the sheet, from the starting time until the solid film has disappeared, is $w_1 \,.\, c_1 \; (T_{12} - T_{13}) \;.\; 2X$, per square foot of sheet.

$$\text{Heating time} = \frac{w_1 \,.\, c_1 \; (T_{12} - T_{13}) \;.2X}{2\,k\,.\,(T_{11} - T_{12})}$$

where w_1 is density of the steel = 488 pounds per cu. ft.; c_1 is specific heat of the steel, for the temperature range from 60. to 786. deg. F., = 0.133; $T_{11} = 850.$, $T_{12} = 786.$, and $T_{13} = 60.$ deg. F., see Fig. 2; X is one-half the thickness of the sheet, ft., and **k** is heat transmission coefficient, Btu per sq. ft., hour and deg. F. For No. 24 gage sheets and for **k** = 400., time = 0.00192 hour = 6.9 seconds.

Taking the length of path through the molten zinc as 5.8 ft., and the speed for No. 24 gage sheets as 35 ft. per minute, the time during which each portion of the sheet is passing through the bath is 10. seconds. From the previous figures, the time required for the surface film of spelter to melt off is 6.9 sec., if **k** is 400 Btu per sq. ft., hour, deg. F. The corresponding distance of travel is 4.0 ft. During the remainder of the time, the sheet is heated above the zinc fusion temperature. The time during which the alloying action can take place is much longer than this, because the zinc coating remains liquid after the sheet has left the bath, until all of the latent heat has been emitted to the surrounding air. The solidification of the coating requires appreciable time, since the rate of emission to the air averages only about 4. Btu per sq. ft., hr., deg. F.

If the rate of heat transfer in the bath were constant, the time required would be directly proportional to the thickness of the sheet, and the speed of travel would be inversely proportional to the thickness. But **k** varies markedly with speed of motion of the sheet relative to the liquid. No test results are available for the heat transmission coefficient from liquid zinc, but when the coefficient is estimated from operating data, it appears that at the speed of 35. ft. per min. **k** is about 400., while for hand dipping (very small velocity), **k** seems to be about 80. Btu per sq. ft., hour and deg. F. By analogy with heat transmission from gases or other fluids to metal walls, **k** should increase in direct proportion to the speed of motion, varying about as shown by the expression

$$K = 80. + 9.\,v$$

where v is velocity of motion of the sheet through the bath, ft./min.

Now if sheets of different thicknesses are galvanized in a given size of pot, and if the solid zinc layer is to be melted off in the same distance of travel, the following relations would hold true:

$$\begin{array}{ccccccc} \text{density} & \times & \text{sp. heat} & \times & \text{temp. rise} & \times & \text{thickness} \\ 488 & \times & 0.133 & \times & 726 & \times & b/12 \quad = \\ \text{area} & & \text{temp. diff.} & \times & \text{coefficient} & \times & \text{time} \\ 2 & \times & 64 & \times & (80 + 9.\,V) & \times & t \end{array}$$

$$t = \frac{4.0\text{ ft.}}{60.\,v}\ \text{hours.}$$

$$V = \frac{8.80}{50.\,b - 1}\,,\ b > 0.020 \qquad \ldots\ldots\ldots\ldots(1)$$

The speeds corresponding to various gages and thicknesses, calculated from equation (1), are shown in the following tabulation:

Gage.	Thickness, inches.	Greatest permissible speed of travel, feet per minute.	Time for surface to reach galvanizing temperature, seconds.
24	0.025	35.0	6.9
22	0.0312	15.6	16.
20	0.0375	10.0	24.
18	0.050	5.9	41.
16	0.0625	4.1	60.

For sheets thinner than 0.02 inch, the velocity would be limited by other than thermal considerations.

As previously stated, the data on rate of heat transfer from the zinc bath are extremely incomplete. In the absence of reliable test results, the coefficients given are the best available.

If the rate of heat transfer were the only factor to be considered, it could be increased by maintaining a hotter bath and greater temperature difference; although, as zinc vaporizes at about 930. deg. F., the gain in this direction is sharply limited. But in any case, there is a factor of even greater importance than speed of galvanizing, namely the production of a coating of just the right thickness. The latter depends very largely upon the viscosity of the liquid, and upon the speed at which the sheet is drawn out of the bath. Definite figures as to viscosity of liquid zinc or its variation with temperature are not obtainable, but beyond question it, in common with mercury and most other liquids, becomes less viscous as the temperature is increased. In other words, raising the temperature of the bath tends to produce a thinner coating. On the contrary, increasing the speed tends to give a thicker coating, for two reasons: First, the shearing forces acting to thin down the liquid zinc film on the sheet, as it leaves the bath, are practically constant in magnitude, whereas the time interval in which they can act, decreases as the speed is raised. This effect, which is well known in galvanizing practice, can be demonstrated very clearly by simple and even crude experiments with other viscous liquids such as syrup or heavy oils. Second, the determining viscosity is not that of the main body of the bath, but that of the liquid very near to the sheet surface. After the solid film has melted off, as previously described, the temperature of the sheet, and of the zinc in immediate contact with it, steadily approaches that of the main body of the bath. But if the sheet is relatively thick and the velocity high, the temperature may not have risen much above the fusion point by the time the sheet reaches the exit rolls (D), Fig. 1. Thus, in spite of the high temperature of the bath, the zinc near the sheet surface, when drawn into these rolls, may be quite viscous, producing a thick coating.

The thickness can be varied independently by other means. Increasing the pressure exerted by the rolls (D) on the sheet, or rather on the liquid film which is carried between the rolls by viscous drag, thins the coating. By providing grooves which carry a small quantity of the liquid up between the rolls to the space (K), Fig. 1, the thickness of coating is increased, to an extent depending upon the size of grooves and quantity of liquid which they transfer.

In spite of these other means of control, viscosity and therefore temperature plays an important part, especially in coating the thicker gases. For instance, if No. 18 gr. sheet is passed through the bath at 15 ft. per minute, it will have reached the fusion point of zinc only a few inches below rolls (D). The zinc film on its surface will be only slightly hotter, corresponding to the steep part of the temperature-viscosity curve, where a few degrees change makes a tremendous difference in the viscosity. Under such conditions, uniform thickness of coating could not be maintained.

Sheet Steel Rolling and Heating

Discussion Written on "Possibility of Improved Methods of Rolling Sheet Steel," Which Appeared in a Recent Issue of The Blast Furnace and Steel Plant.

By EVAN LLEWELLEN

THE technique of the art, like the early history of iron making, being involved in more or less obscurity, the writer, with an experience of 40 years and through a close association with the older ones possessing an intimate knowledge of what transpired during a few years prior to that, wishes to offer a few remarks in answer to Mr. Sumner B. Ely's candid acknowledgement that but little is known about the work, as appeared in The Blast Furnace and Steel Plant magazine, where he discussed the "Possibility of Improved Methods of Rolling Sheet Steel," leaving it to the judgment of Mr. Ely and others as to whether this will or will not add to the difficulties of the continuous method of rolling light gauge sheets.

It is common today to smile when we hear about the seven to 10-ton housings, the 20-inch rolls and the old steamboat engines used to pull such mills, but it is unwise to imagine that any crudeness existed in the rolling and heating of that period, for a very fine product was being turned out in black, galvanized and high finished sheets, so that in point of quality we have progressed little if any in the last 50 years at least.

Great progress has been made in the way of increasing the weight of the housings and the diameter of the rolls in order to meet the demand for increased output, in the strength of the machinery enabling the workmen to dispense with almost half the number of passes formerly used in drawing the sheets out to the required lengths, especially with steel of a composition calculated to stand a rather high heating temperature, carbon and phosphorus being used in the right proportions for this purpose, and to prevent welding together of the sheets while being rolled in packs.

However, in order that the operation will be successful, a uniformity of heating must obtain so that all of the sheets will draw out alike, thus not breaking up the thin coating of magnetic oxide formed by the initial heating and rolling and which is firmly adherent to the sheet; for the sheets will weld together where the bare metal surfaces meet; but the fact that a high temperature can be used better guarantees a balanced furnace temperature.

But it is the same with light sheets as with any other steel or iron product—the higher the heating and finishing temperature and the smaller the amount of working which the steel receives the larger will be the grain size, so that while this may secure a larger production the sheets are of indifferent quality, though suitable for many purposes.

Along with such a product there is a growing demand for smooth surfaced sheets calculated to stand stamping into all conceivable shapes, necessitating a composition that is almost free from hardening elements. Thus, insofar as heating requirements are concerned, we are getting back to the days of refined iron which required a very low heating temperature.

Contrary to present-day opinion of sheet workers, the rolling, and particularly the heating of sheets, had been reduced to a fine art by that time, the intricacies of the method being kept shrouded in an air of mystery with the tendency for the jobs to descend from father to son or some favored friend, thus retarding the advancement of other and perhaps more progressive young men. In the accomplishment of its purpose this attitude was necessarily short lived, since any bright man had but to copy the tactics employed in manipulating the fire, there being no necessity for him to understand the chemistry involved in the process of gas-firing, which was the method employed when burning coal.

Because of its large heating chamber the sheet furnace is peculiarly adapted to this method of firing when a very low temperature is desired, the upper portion acting as a holder in which the gases become thoroughly mixed, leaving ample room below for combustion. This makes for a balanced temperature, and the atmosphere must not be confounded with that of a muffled furnace, for while the damper is raised there is a well regulated flow of air up through the fire, the raising or lowering of the damper making the possibilities of control quite definite and easy.

Great importance was attached to the compactness of the fuel bed, the idea being to avoid any local high temperature and the letting in of free oxygen (together with undecomposed carbon dioxide) which condition not only unbalances the temperature, but destroys the mildness of the furnace atmosphere.

Considerable open-furnace annealing was practiced in the early days, necessitating a strict avoidance of any oxidizing elements coming in touch with the metal. In fact, oxidizing elements have no place in the sheet-furnace at any time since oxygen with carbon dioxide freely enters between the sheets while they are as yet cold and just as soon as the bundle or pack of sheets begins to absorb heat the carbon dioxide, in the writers' opinion, decomposes into its constituent parts and the oxygen combines with the metal in the formation of a loose spongy scale which emits a smouldering gas. This chemical reaction seems to be exothermic and effervescent, its intensity depending upon the temperature of the pack and the friction of rolling as is evidenced by the variations in the expansion of the enclosed gas in causing separation of the sheets and the appearance of the scale upon the interior surfaces of the sheets after rolling.

Steel expands with heating, leaving the pores open to absorb deleterious gases with the usual hardening effect noticeable with light sheets in that they do not settle together in proper cohesion necessary to exclude the but partially burned gases with which the heater surrounds the packs in an attempt at soaking shortly before finishing, therefore the old Welsh trick of checking further calorific power by dropping the damper and allowing the absorbed heat to become thoroughly diffused throughout the pack is not practical in an oxidizing atmosphere, and annealing is entirely out of the question.

With the introduction of natural gas into the mills of the Pittsburgh district many years ago, many and varied types of combustion chambers were brought out. Only one of these proved to be the acme of perfection in the production of a continuous and unfailing non-oxidizing atmosphere, but the principles underlying the method of operation were not generally understood and so it was not picked out and standardized.

The present standards of rear chamber construction and operation seem to be at variance with these older ideas insofar as the volume, temperature and composition of the gases are concerned and the point in the furnace where the actual combustion takes place. As to the different fuels used, their relationship is fixed by physical law so that all failures can be ascribed to a non-observance of these simple scientific facts which the early Welshmen tried to conceal from the Yankee. It is evident that these principles had been thoroughly and scientifically analyzed before the business was introduced into this country.

ELEVENTH ANNUAL SAFETY CONGRESS

The program of the Eleventh Annual Safety Congress of the National Safety Council at Detroit, August 28 to September 1 is now complete. On July 15, a printed copy of the entire week's sessions, together with a formal invitation from the Detroit Safety Council and supplemented by a personal letter from President Arthur H. Young, calling attention to the points of greatest interest during the five-day program will be sent to 15,000 executives and safety men representing supervision over six million and more workers in the United States and Canada.

Indications now are that the 1922 Safety Convention will be the largest and most complete in the history of the National Safety Council. Never before in the history of the organization has response to invitations to participate in the Annual Safety Congress been so spontaneous. Public officials, industrial executives, well known authorities in research, science and education, have volunteered to appear on the programs to do their bit for national safety.

The first day's program may be taken as a criterion for the quality of each and every meeting during the week. On this day a short business meeting will precede, in the morning, talks by Edgar A. Guest of the Detroit Free Press, Judge C. L. Bartlett of the Detroit Court of Records, and an address of welcome by President Samuel C. Mumford of the Detroit Safety Council, and others. In the afternoon Dr. John Wesley Hill, Chancellor, Lincoln Memorial University and author of "Abraham Lincoln—Man of God," R. M. Little, Director of Rehabilitation, New York State Department of Education; A. H. Lichty, Vice-President, the Colorado Fuel & Iron Company and Dr. J. J. Tigert, Commissioner of the U. S. Bureau of Education, will speak on four important aspects of national safety—Educational, industrial, public, and national safety. A feature of this program will be an excellent presentation dramatizing the subject suggested by a recent Council bulletin entitled "Was Daddy Hurt Much?"

Complete discussion of the various phases of industrial and public safety will be had at the meetings of the twenty different sections into which the Council's activities are divided. These meetings will cover safety problems in the automotive, cement, chemical, construction, metals, paper and pulp, packers and tanners, rubber, textile, woodworking, electric railway, public utilities, steam railroads, mining, public safety, educational, engineering, drop forge, health service and women in industry divisions.

Centrifugal Casting

Giving the Benefits of Making Centrifugal Castings in Vertical Molds Rather Than in Horizontal Molds As Is Customary—Theoretical Calculations Necessary for Method Are Given.

By N. LILIENBERG*

ALTHOUGH the casting of metals hollow by centrifugal force in rotating molds has been practiced a long time in a limited scale it is only within the latest years that it has developed into important production. The object is well known to be saving of expense, avoiding casting over core and obtaining liquid compression.

The cores are especially objectionable in casting low carbon steel which shrinks about the double of cast iron or semisteel and therefore is liable to produce surface cracks.

The compression by centrifugal force can be increased beyond the strength of material evidenced by the occasional bursting of heavy rims of flywheels and by the especially strong steel needed for milk-separators.

The centrifugal force is: $C = \frac{m \,.\, v^2}{r}$, in which m = the mass $= \frac{w}{g}$, w = the weight, g = the acceleration of gravity = 32.2′, r = the radius, v = the circumferential velocity $= \frac{\pi \;\; r \,.\, n}{30}$, n = number of revolutions per minute, $\pi = 3.1415$.

If one cubic inch of steel weight about 0.26 lbs. is rotated on a radius of 6 in. at 500 revolutions per minute:

$$C = \frac{0.26}{32.2} \times \frac{\pi \,.\, 500 \,.\, 0.50^2}{0.50} = 11 \text{ lbs.}$$

and if the speed is increased to 1,000 rpm the strain on the tie to the center will be 44 lbs. exerted by only 1 cubic inch.

As far as I know centrifugal castings in quantities have been made only in horizontal molds. It is more simple in operation and construction to cast in vertical molds whereof I have been convinced by experiments and calculations.

It is in order to first give the theoretical calculations.

1. The Centrifugal Parabola.

That a rotating liquid forms a hollow, shaped as a paraboloid, can be demonstrated as follows: In Fig. 1 the letters represent the above named quantities and in addition dY = the differential of Y and dX = that of X.

$$C = \frac{\pi^2 \,.}{g \,.\, 30^2} \,.\, n^2 \frac{.\, X^2 \,.\, w}{X}.$$

For convenience I call $K = \frac{\pi^2}{g \,.\, 30^2}$

$$C = K \,.\, n^2 \,.\, X \,.\, w$$

As the liquid places itself at 90 degrees towards the resultant of the centrifugal force and the weight of each particle

$$C \,.\, \text{tang } a = w \,;\, .\, K \,.\, n^2 \,.\, X \,.\, \text{tang } a \,.\, w = w\,;$$

The tangent of the curve forms the same angle a with the vertical:

$$dY \,.\, \text{tang } a = dX \,;\, \text{tang } a = \frac{dX}{dY} \,;\, K \,.\, n^2 \,.\, X \,.\, \frac{dX}{dY} = 1\,.$$

By integration:

$$K \,.\, n^2 \int X \,.\, dX = \int dY \,;\, \frac{K \,.\, n^2}{2} \,.\, X^2 = Y,$$

which is the equation of a parabola.

Fig. 2 shows how rapidly the length of the parabola increases with the speed forming practically straight lines with small differences in diameters in the part cut off in the mold.

2. Calculating the Volume of the Liquid and the Speed, to Produce Determined Results. Fig. 3.

The volume of a paraboloid is ½ of the circumscribed cylinder.

It is evident that the volumes excavated below the line of rest, and raised above it as indicated by the shaded parts in Fig. 3 shall be equal that is: $V_1 = V_{111}$, which means

$$\tfrac{1}{2} \,.\, \pi \,.\, X^2 \,.\, Y_1 = \pi \,.\, r^2 \,.\, Y_{11} - V_{111}$$

$$\pi\, r^2 \,.\, Y_{111} - \tfrac{1}{2} \,.\, \pi \,.\, r^2 \,.\, (Y_{11} + Y_1)$$

$$+ \tfrac{1}{2} \,.\, \pi \,.\, X^2\, Y_1$$

$$\tfrac{1}{2}\, r^2\, (Y_{11} + Y_1) = r^2 \,.\, Y_{11} \,;\, \tfrac{1}{2} \,.\, (Y_{11} + Y_1) = Y_{11} :$$

$$Y_1 = Y_{11}.$$

The length of the paraboloid is:

$$Y = \tfrac{1}{2} \,.\, K \,.\, n^2\, r^2$$

For a 6 in. mold $r = 0.25'$.

With $n = 100$; $Y = 0.106'$
$n = 250$; $Y = 0.66$
$n = 500$; $Y = 2.65$
$n = 750$; $Y = 5.95$
$n = 1000$; $Y = 10.60$ feet.

I call the line to which the liquid rises without rotation the line of rest. As it has been demonstrated that this line divides the length of the paraboloid in two equal parts

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*The author is a consulting engineer on the manufacture of centrifugal steel castings, located at 283 Rochelle Ave., Philadelphia, Pa.

$$\tfrac{1}{2} . K . n^2 . r^2 = Y$$

$$\tfrac{1}{2} . K . n^2 . X^2 = \tfrac{1}{2} . Y$$

$$X = \sqrt{\tfrac{1}{2}} . r = 0.707 . r$$

All the parabolas, independently of speed therefore intersect the line of rest at a constant distance from the center.

This as well as the equal division of the length hold good as long as the apex stays inside of the mold.

The speed at which the apex touches the bottom of the mold can be calculated as follows, Fig. 3:

$$\tfrac{1}{2} . K . n^2 . \frac{r^2}{2}\ h;\ K = \frac{\pi^2}{g . 30^2}$$

$$n = 108.75 . \sqrt{\frac{h}{r}}$$

When the speed is increased beyond the last named limit, an imaginary paraboloid forms below the bottom of the mold, Fig. 4. The line of rest then no longer divides the length of the parabola in halves.

V = volume poured in the mold.
V_1 = the trunkated paraboloid.
V_{11} = cavity over line of rest.
V_{111} = volume of liquid raised above line of rest.
V_{1v} = volume of imaginary paraboloid below the bottom.

$$V_{11} + V_1 + V_{1v} = \tfrac{1}{2}\pi . r^2 (Y_{11} + h + Y_{1v})$$

$$V_1 = V_{11} = \tfrac{1}{2} V$$

$$V = \pi . r^2 . h;$$

$$V_{1v} = \tfrac{1}{2} . \pi . X^2_1 . Y_{1v};$$

$$Y_{1v} = \tfrac{1}{2} . K . n^2 . X^2_1$$

$$V_{11} + \tfrac{1}{2} V + \tfrac{1}{2}\pi . r^2 (h + Y_{1v}) -$$

$$\tfrac{1}{2} V = \tfrac{1}{2}\pi r^2 (Y_{11} + h + Y_{1v}),$$

$$V_{11} = \pi . r^2 . Y_{11} - \tfrac{1}{2} V;$$

$$Y_{11} + h + Y_{1v} = \tfrac{1}{2} K . n^2 . r^2;$$

$$Y_{1v} = \tfrac{1}{2} K . n^2 X_{1v}$$

$$K = \frac{\pi^2}{g . 30^2}$$

From these equations is obtained:

$$\frac{4 . r^2 . h}{K . n^2} = (X^2_1 - r^2)^2;$$

$$\pm \sqrt{\frac{4 . r^2 . h}{K . n^2}} = X^2_1 - r^2;$$

$$r^2 - \sqrt{\frac{4 . r^2 . h}{K . n^2}} = X^2_1$$

$$\sqrt{r^2 - \frac{2.30}{\pi}\ \sqrt{g} . \frac{r}{n} .\ \sqrt{h}}$$

$$X_1 = \sqrt{r^2 - 108.75 . \frac{r}{n} .\ \sqrt{h}}$$

This gives the radius of the opening at the bottom of the mold = X_1. If $X_1 = 0$, that is if the apex just touches the bottom

$$r^2 = 108.75 . \frac{r}{n}\ \sqrt{h};\ n = 108.75 .\ \sqrt{\frac{h}{r}}$$

which is the same as the above given formula.

For a 6 in. mold, r = 0.25′ and if then h = 1′, n = 750, the radius of the opening at the bottom will be X_1 = 0.165$_1$ = about 2″ and the thickness of the casting about 1 inch.

To produce a bottom wall thickness of ½ in. the speed would have to be n = 1,288. If h = 0.50′, n = 750, r = 0.25′, X = 0.1,936′ and the bottom wall thickness = 0.055′ = 0.67″.

When r^2 gets smaller than $108.75 . \frac{r}{n} . \sqrt{h}$, the proposition of course becomes absurd.

If the rising liquid strikes the cover of the mold, a pressure is exerted equal to the weight of the top part thereby cut off and in addition the upward pressure of the same part which turned down gives additional thickness to the walls. All of this can be calculated with the above named formulas. But the deductions are somewhat lengthy to appear in this article.

The strength of the mold to resist the pressure can of course be ascertained by calculations which are too well known to be here repeated. With the comparatively moderate speeds used in this process, there is usually no cause for adding any extra strength to the parts in operation.

3. Casting Apparatus. Fig. 5.

The frame is made of two standing round bars of cold rolled steel the lower ends being fixed in a cast-iron bottom plate, the upper ends entering through a cast iron cross piece. The bed plate is securely bolted to a solid foundation and the upper cross piece is held by stay bolts anchored to the walls of the building. The frame must be rigid as the slightest vibrations make the castings defective. A moving shaft is standing in the bottom plate with end thrust on ball bearings. The pulley on the shaft is adjusted according to the motor.

As one motor may drive several machines it is well to have also one idle pulley so that each machine can be stopped separately. The upper end of the shaft moves in a bearing inserted in the cross piece. This as well as the top cross piece are held in place by tubes out to proper lengths and pulled over the bolts. When the nuts on the top are tightened the frame is rigid. The upper end of the driving shaft carries a disk of diameter suitable for the mold and provided with two projecting sectors forming a driving clutch.

The cover of the mold has a hole through which the spout for the pouring enters. This spout which holds the mold in position is fixed in a cross piece made to slide on the tubes surrounding the frame bolts. The strain on this spout is small because the mold

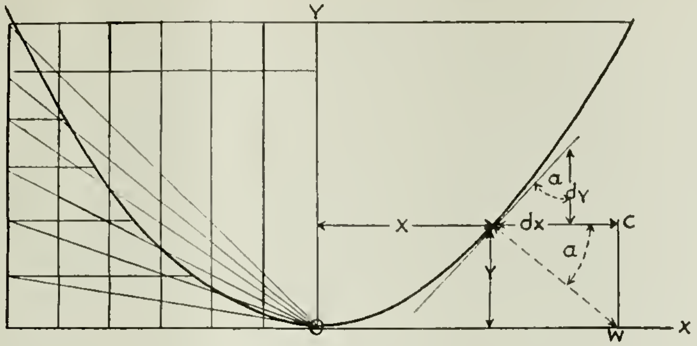

Fig. 1

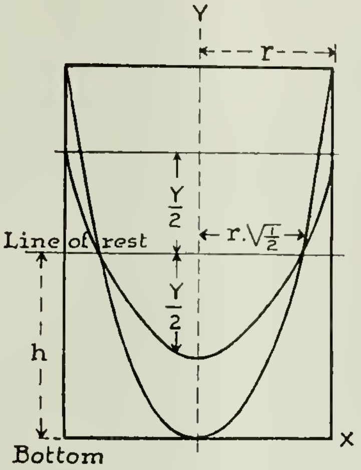

Fig. 3

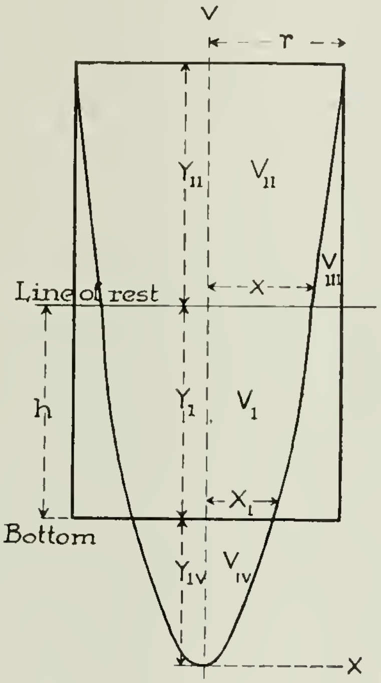

Fig. 4

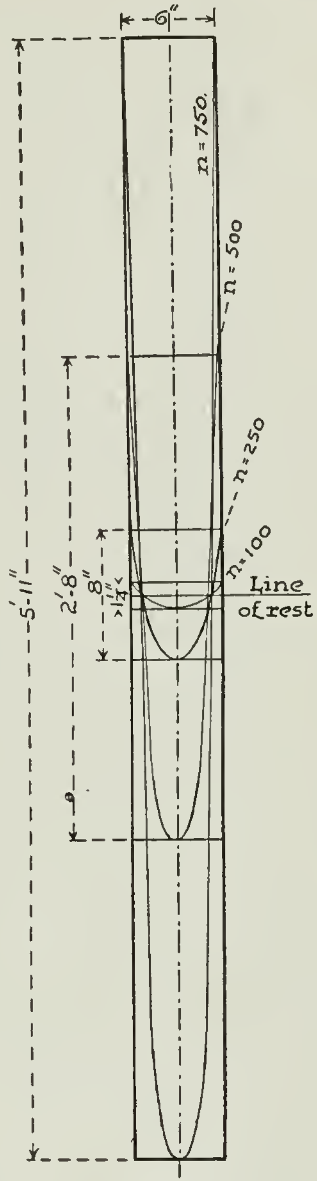

Fig. 2

Scale 1½" = 1'

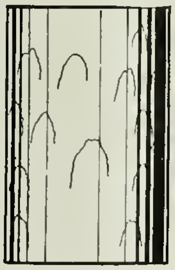

Fig. 6

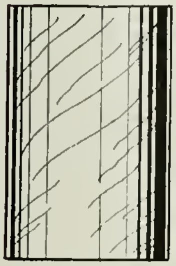

Fig. 7

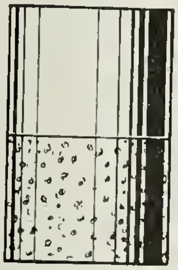

Fig. 8

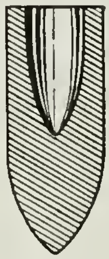

Fig. 9

straightens up automatically following the laws of gyration which makes a spinning top stand upright without support. The cross piece containing the spout and funnel for casting is connected by rods to a hydraulic plunger in a cylinder placed on the top. When the casting is finished the spout is lifted up above the mold. This is thus free to be removed as it is standing loose on the rotating platform with only the top of the driving shaft inserted in the center. Another mold standing close by is then put in its place. This operation only takes a few seconds. The mold will have to be perfectly centered because the least vibrations cause the walls of the casting to be uneven in thickness.

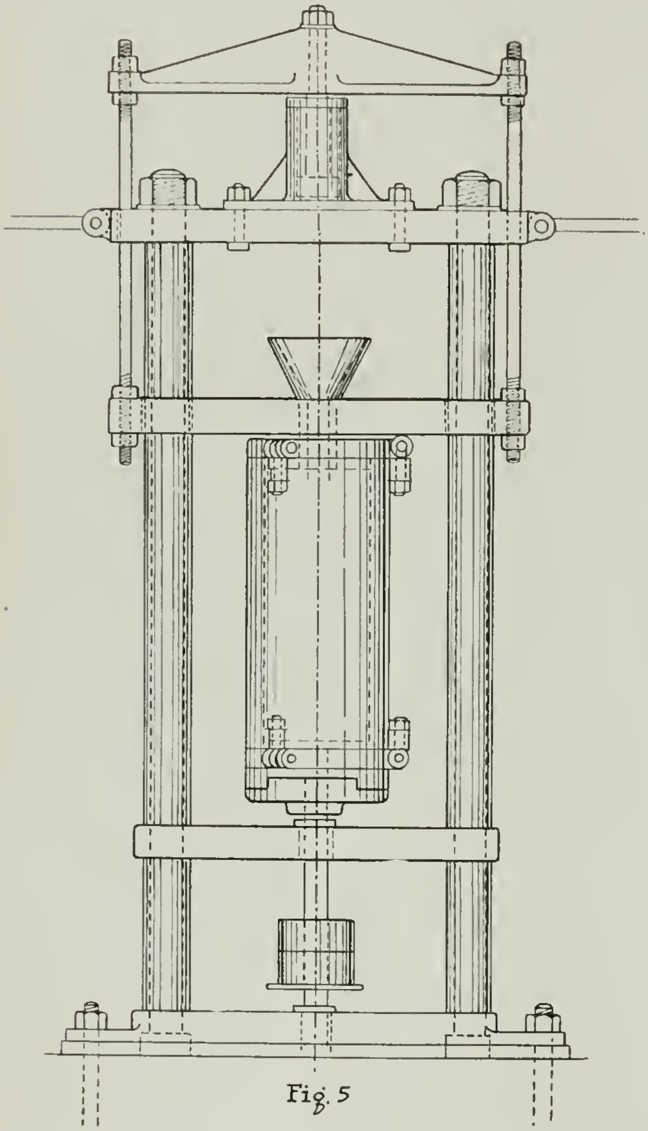

Fig. 5

The casting can be released from the mold:

1. By making the mold divided lengthwise clamped together so that it can be opened quickly. But it is not always possible to prevent fins forming in the joints. It can therefore not be used in cases where those fins are objectionable in further working.

2. By having the bottom and the cover loose and fixed to the mold by bolt clamps, in such a way that they can be easily detached. The mold is then rolled into a stripper, which forces out the casting by hydraulic.

3. By the driving shaft entering the bottom of the mold and being attached to a movable inside bottom. While the mold is held down the shaft with the bottom is pressed upwards by hydraulic and forces the casting out of the mold. This operation in itself is the easiest and most rapid but the apparatus becomes complicated, more time is consumed between the castings than by removing the mold, but above all it is objectionable to cast on an inside false bottom. If this is made tight from the beginning it will swell by the heat so as to make it stick. If it is made loose some metal will run out in the joint.

4. Casting.

When the liquid strikes the bottom of the mold rotating at full speed it is instantly thrown up against the sides. In a mold of cast iron cold splashes will then form as indicated on Fig. 6. The seams between those splashes will be deeper in proportion to the difference in temperature between the metal and the mold. Low carbon steel and cold cast iron molds present in this matter an extreme case. Cold splashes occur however quite frequently in ordinary stationary molds cast from the top through the bottom of a ladle containing the whole charge. This especially happens in the first cast ingots when the speed of the jet is accelerated by the whole overlaid height of metal in the ladle. But the splashes are worked away in further operations. This may therefore be done in some cases of centrifugaled castings but in others it cannot be done. By heating the mold the clefts between the splashes become less deep and the metal is kept liquid longer. But if the heat shall do any good it will have to be raised so high as to come dangerously near the temperature where the melted metal attacks the cast iron mold. The same object will be obtained by having the mold clay lined, but the surface of the casting will get rough and require more working to be acceptable.

By experimenting with melted parrafine in brass mold I have found that cold splashes are avoided by arranging the inserted spout so that the liquid is discharged horizontally impinging on the sides of the mold where the centrifugal force places it. The appearance is somewhat like Fig. 7 with helical marks very faint and shallow.

By pouring the liquid in a stationary mold and then rotating, I found that the casting presents an appearance somewhat like Fig. 8. The part below the line of rest has the appearance of an ordinary cast ingot with surface blow holes, if the steel is not dead molten and cast at a low temperature. But the upper part presents a perfect outside surface. The demarcation line between remains however quite deep and distinct.

If the mold is made to rotate slowly during the casting and then brought up to full speed there will be no such demarcation line. The lower part has a surface no worse than ordinary cast ingot but the upper is so near faultless as can be. In both of the last named cases a solid bottom closes up the casting which however can be either cut off or pierced in further working. This solid bottom gives the advantage in stripping that the pressure can be exerted only by a rod forced in the center hole fitting over the upper end of the driving shaft and the bottom of the mold needs not to be detached.

The inside of the casting follows faithfully the paraboloid cut off in the mold. As shown above even at a moderate speed the parabola straightens out to practically a trunkated cone approaching a cylinder. Tube makers do not object to a slight difference in the diameter in both ends, but a cross section anywhere must show the same thickness all around because any uneveness in that respect can not be corrected by any subsequent working. In a vertical smooth running mold the centrifugal force takes care of this matter as it is not one sidedly affected by the gravity. Although the inside is perfect in shape the pretention that it shall be so smooth as the outside is of course unreasonable. With exception of cast iron hollows it will have to be worked into shape. For the case of tube billets to be rolled over mandril it is therefore advisable that the inside be first reamed out which could easily be done in the same operation as forcing out the casting from the mold.

In all centrifgual castings a measured quantity of liquid metal has to be poured into the mold, which means pouring over lip from hand-ladles. The melted charge has then to be kept hot while waiting. To accelerate the pouring and make it so continuous as possible it is preferable to have 3 machines to be used alternately.

The technically most suitable process is of course crucible melting. But this is now being relegated to the rear on account of the high expense of fuel and crucibles especially in producing the high temperature for melting low carbon steel. A small electrical melting furnace will of course answer the purpose if the steel can be kept in the furnace long enough without changing composition in contact with the basic bottom and phosphoretic slag (there have been cases where the carbon in the steel reduces back some phosphorous out of the slag by long contact after refining).

A 2-ton side blow converter seems to fill the requirements. The casting from such a converter through hand ladles is done just in the same way as it would be in serving centrifugal machines. The steel is kept hot in the converter on an acid bottom, covered by a blanket of acid slag and exposed to the radiation inside the converter. The slag is held back by closing the mouth of the turned down converter with bricks and the clear steel is tapped from the lowest point. By the operating mechanism the turned down converter is raised and lowered so as to measure off exact quantities in the hand ladles. The steel is hotter than in any open-hearth furnace or bottom blown converter as the carbonic oxide is burnt in side the converter, and the heat is only second to that in an electrical furnace. A 2-ton charge of pig iron melted in a cupola is converted into steel in about 20 minutes without any consumption of fuel, which is shorter operation than refining in basic electrical furnace. The side blow converter is cheaper to install and operate than an electrical furnace, the only outfit being a 60 horsepower positive blower for pressure of 3 to 4 lbs. per sq. in. and a 5 horsepower tilting apparatus.

But on the debit side stands the higher price of the low phos. pig iron to be used in the converter and the exclusion of scrap. Common steel scrap is cheaper than pig iron and the charge in a basic electrical furnace of such scrap and phosphoretic pig iron is lower in price than the charge in a converter.

Operating with small units in any furnace is of course always more expensive than for inst. melting 100 ton charges in a basic open hearth furnace. But it would be impossible to use this for measuring off small quantities, as the whole charge has to be emptied in one ladle. Even if the steel could there be kept hot for the required long time it would be impossible to pour through the bottom into hand ladles as the pressure would make the steel flow over and spill.

5. Products.

Although, as shown above the centrifugal parabola rapidly elongates with the speed, there is of course a limit of length for vertical casting. But the majority of hollow articles fall within that limit. A cast tube with the inside tapering off to an edge, can be divided up, the upper part being used direct for drawing, the lower part used as hollow billets to be rolled over mandril.

The ordinary way of making hollow tube billets is to cast 12 in. ingots, reheat these in gas fired soaking pits, reduce the size in a blooming mill to 6 in., cut up the blooms into lengths suitable for heating and rolling into round billets, saw off these to lengths, heat and roll between disks in such a way the billet is forced against a stationary spear. On the face of it hollow billets can be worked out cheaper by centrifugal casting.

Among the many articles of limited length to be cast vertically by centrifugal force I call special attention to the following two:

The sleeves to be shrunk over the explosion chamber of a field or siege gun can be made quite satisfactory in that way and much cheaper than by the present elaborate process.

Projectiles can be made centrifugally, about as good as forged and the cavity closely conforms to the required construction, Fig. 9. All projectiles whether cast or forged have to be machined to exact finish—I found by experiments with parrafine that a small stationary pool will remain at the point of the cavity which afterwards forms a short pipe. But even this is easily corrected in further working. The great advantage is the forming of the cavity thereby saving the tremendous labor of carving out the hollows cold from forged solid blanks by using a great number of machines.

It would be interesting to fill a rotating mold so completely that no cavity can be formed and to ascertain the effect of the centrifugal force by the microstructure.

In all the above said I have mentioned the most difficult metal which is low carbon steel to be thus treated. The work with other metals is comparatively easier.

IRON MINING PROBLEMS IN BIRMINGHAM DISTRICT

An investigation in progress at the Southern experiment station of the Bureau of Mines, Birmingham-Tuscaloosa, Ala., relates to the location of low-grade high silica iron ores, the support of mines and the ventilation of the mines of that district. Large blocks of iron ore will be cut to uniform size and tested with a view to determining their crushing strength as a basis for the calculation of size and arrangement of pillars in the mines. Subsidence in iron mines will also be investigated, involving a careful study of surface and underground conditions. Metal-mine ventilation and the dust problem are to be studied in a manner similar to that which has been followed by the Bureau of Mines in certain metal-mining districts of the North and West.

Fuel Economy in Heating Furnaces

New Methods to Obtain Increased Production With Decreased Fuel Consumption from Regenerative and Recuperative Furnaces.

By K. HUESSENER
Mgr. American Heat Economy Bureau, Pittsburgh, Pa.

NOTWITHSTANDING the fact that regenerative and recuperative furnaces have been in use for close to half a century, there are no generally recognized rules governing their design. Most builders of furnaces have their own set ideas, mostly based on empirics. This is, not by any means, confined to any particular country, but holds true all over the world. One eminent German authority is quoted to say quite recently that metallurgical furnaces differ from stables more in material used than in any other way, thus reducing the matter ad absurdum. May that as it be, there is no denying the fact that a large majority of furnaces are of haphazard design, rendering it extremely difficult for the operator to obtain satisfactory results.

In examining heating furnaces from a strictly theoretical point of view, we find that output and economy go closely hand in hand—as the following simple calculation will show, using the following characters:

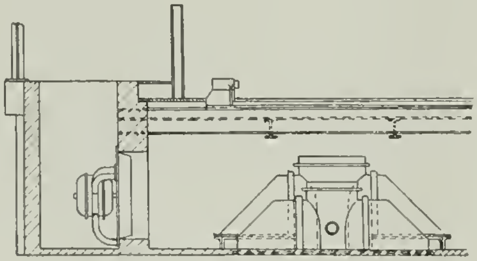

Fig. 1.

W = sensible and latent heat of gas and air admitted at the port

W′ = heat remaining in the furnace

N = heat transmitted to the material (process heat)

S = heat transmitted to the walls (radiation and conduction losses)

$$W' = (N + S)$$

(W — W′) = E = heat going into the outgoing regenerators

N′ = heat transmitted to gas and air by regeneration

S′ = wall losses of the regenerators

E′ = heat going to the stack

$$E = (N' + S' + E')$$

G = weight of waste gas resulting from combustion of W

c = specific heat of waste gases, assumed to be the same for all parts of the furnace

ta = calculated initial temperature

te = temperature of waste gases entering the regenerators

We obtain the following equation illustrating the course of the heat through the furnace:

$$W - (N + S) = N' + S' + E'$$

The heat contained in W is equal to the weight of the waste gases multiplied by the specific heat and the calculated temperature

$$W = G\ c\ ta$$

which is reduced when entering the outgoing regenerator to:

$$E = N' + S' + E' = G\ c\ te$$

therefore the heat remaining in the furnace

$$W' = (N + S) = G\ c\ ta - G\ c\ te$$

and as the efficiency of the hearth is expressed by the relation of the heat admitted to the heat retained:

$$\frac{G\ c\ ta - G\ c\ te}{G\ c\ ta} = \frac{ta - te}{ta}$$

The efficiency of the furnace is therefore in direct relation to ta and in reversed relation to te. Very little influence can be exercised on te which is bound to be above the temperature of the treated material. The attention of the operator must therefore be given to obtaining as high an initial temperature as is consistent with the material used in building the furnace, and with the process temperature required.

We have, however, seen that only part of the heat remaining in the furnace is transmitted to the bath or the heated material, and that another part, unfortunately the greater, is transmitted to the walls and lost through wall loses. These wall losses are not in any way dependent on the quantity of heat W admitted, but are governed by the difference of temperatures of the inside and outside of the furnace walls. They are, therefore, for any given type of furnace and temperature ta, fixed losses and their percentage proportion to the heat W admitted will be in a reversed relation to the quantity of this heat.

We have seen that:

$$N + S = G\ c\ ta - G\ c\ te$$

or

$$N = G\ c\ (ta - te) - S$$

In other words, once the highest admissible temperature ta has been attained, te and S being fixed quantities, N the heat transmitted to the material is dependent on the G c, which in turn is dependent on the quantity of latent and sensible heat admitted in gas and air.

In following the course of the waste gases through the outgoing regenerators we find that

$$G\ c\ t_e = N' + S' + E'$$

or

$$N = G\ c\ t_a - (N' + S' + E') - S$$

As G c ta is made up of Wl, the latent heat in the gas, and Ws, the sensible heat in gas and air, and Ws = N', or

$$N = (Wl + WS) - Ws + S' + E' - S = Wl - (S' + E') - S$$

we find that the efficiency of the furnace will increase with the increase of the latent heat and the decrease of the stack losses E'. The wall losses of the regenerators S' being fixed quantities same as the wall losses of the hearth S for the above stated reasons.

In order to reduce the chimney losses as much as possible it will therefore be necessary to store as much heat N' as possible in the outgoing regenerators and take it up again as Ws in the incoming regenerator. The heat transfer in the regenerators is almost exclusively by contact and is therefore in direct relation to the velocity of the gases passed through them, and to the squares of the absolute temperatures. If larger quantities of gas and air are passed through the regenerators this will certainly result in larger velocities. We have seen that te must be considered a fixed temperature, so that when working with larger quantities of waste gases the heat transfer will only be benefited by the velocities in the first outgoing period. On the next incoming period the larger quantities of gas and air, if both cold, or at least of the air only, if hot producer gas is used, will result in cooling the regenerators to a lower temperature and thus also assist the heat transfer, with the result that E' is correspondingly reduced. How far a reduction of the chimney gas temperature when working with larger quantities of gas is actually possible, will depend on the size and design of the regenerator, but experience has shown that the chimney temperatures are as a rule not increased where the load put on the furnace is increased, so that the final efficiency is as a rule not unfavorably affected by the chimney losses.

The calculation proves that to obtain better efficiencies from any given furnace it is necessary to increase the initial temperature and to pass as large as possible a quantity of heat through it.

To refer to the latter requirement first, it must be kept in mind that the amount of gas which can properly be burned in any given furnace depends on the sizes of the regenerators and of the stack, the former to provide as large as possible a quantity of gas and combustion air, the latter to convey a correspondingly large quantity of waste gas to the waste heat boilers or into the atmosphere. On account of the fact that the gas regenerators are usually of the same size as the air regenerators and that the gas is supplied to them under pressure, there is in the majority of cases no difficulty to supply very much larger quantities of gas to the furnace. Not so with the air. The air enters the air valves under atmospheric pressure and its quantity is dependent on the chimney effect of the regenerator.

In examining the possibilities of a furnace, one will first of all ascertain whether the air valves are wide open during operation, and to what extent the possibilities of the stack are utilized. In case one finds that one operates with wide open air valves and partially closed chimney damper, the conclusion is justified that the furnace can deal with more gas, provided that the air supply is correspondingly increased. The possibilities of the stack are only exhausted when with a wide open damper balanced draft is maintained in the hearth. A large enough chimney is, therefore, always a chief requirement for the proper utilization of a furnace. In case the chimney should be too small it will almost always pay to equip it with an exhaust fan.

To provide more air was hitherto not simple. Larger regenerators which offer the obvious remedy are in the majority of cases out of the question on account of lack of space, quite apart from the expense. To supply the regenerators with air under pressure by connecting the air valve to an air duct and blow air into this duct by a fan forbids itself in the majority of cases for various reasons.

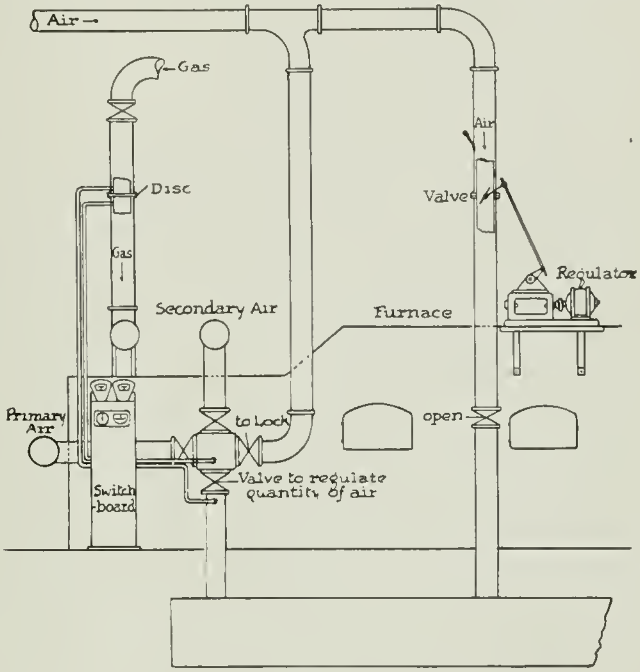

Fig. 2.

The great majority of air valves are situated either in valve pits, or in cellars, and are usually so crammed in that it is impossible to accommodate the air duct and the fan. It might be possible to provide a long air pipe and locate the fan outside the pit or cellar. The result, however, would be total loss of ventilation and such an increase in heat in the pits that it would be impossible for the men to work in them and to give valves, levers, etc., the required attention. The increased heat in the pits would naturally also result in greatly increasing the temperature of the floors on which the men are attending to the furnace.

Another very vital objection to this kind of air supply is the fact that the furnace becomes dependent on the working of the fan, and in case of breakdowns of the fan motor or the central power plant, the furnace would be closed down.

A method of supply of air which overcomes all these objections, and which for some years has been used with very great success on a number of heating furnaces, has been developed and patented by Mr. Alfred Steinbart. Instead of using the ordinary centrifugal fan and the air duct, he arranges the pit in such a manner that it is as nearly as possible air-tight and equips it with a propeller fan built into one of the walls of the pit. (See illustration.) Where the valves are situated in cellars he builds a small casing around the valve and equips this casing in the same manner with an ordinary propeller fan.

The regenerator usually creates a draft of about 2/10 in. w.g. which determines and limits the quantity of air to be handled by it without outside assistance. In order to increase this quantity a certain additional outside pressure has to be set up. Assuming that the chimney effect of the regenerator of 2/10 in. w.g. can handle 5,000 cu. ft. of gas per minute, and it is desired to increase this quantity by 25 per cent to 6,250 cu. ft. per minute, the pressure to be set up by the fan (x) is found from the following equation:

$$\frac{\sqrt{.2}}{\sqrt{.2 + x}} = \frac{5000}{6250} = \frac{5}{6.25}$$

(The quantities of air passing through a given area are in proportion to the square roots of the static pressures in inches of water.)

A propeller fan to set up this additional pressure of 1/10 in. w.g. requires a little over 1 hph. The 25 per cent additional air will as a rule be sufficient to increase the output of the furnace by 30 and more per cent.

An installation of this kind has manifold advantages. Besides being inexpensive, the installation can be made without stopping the furnace. If the fan for any reason whatsoever should break down, the furnace will not be stopped as the old conditions of air supply can immediately be restored. In addition to supplying the furnace with additional air, it also supplies welcome ventilation and cools the floors on which the men are working. By chosing the fan a little larger than its actual requirements, this ventilating and cooling effect can be made very pronounced, so that the men can work in the pits without experiencing any inconvenience.

The following table gives an idea of the results obtained from an installation of this kind. A furnace having a hearth surface of 7 ft. 9 in. by 6 ft. 5 in. between bridge walls, and heating to a welding heat plates 6 in. wide, 29 in. long and ⅝ in. thick, weighing 30 pounds each, was changed over to the Steinbart method of air supply. The following are the number of plates heated before and after the installation during each shift:

Before	*After*
718	886
712	497
863	616
926	790
625	682
741	820
588	787
550	888
636	1244
800	1460
878	1520
1074	1508
904	1107
480	1129
10,495	13,934

The average run per shift before the installation was 750 plates and after the installation 995 plates, an increase of 32 per cent.

When, a short time later, the fan was stopped, one Saturday morning, the results were as follows:

9:00-10:00 A. M.	126
10:00-11:00 A. M.	130
11:00-11:45 A. M.	97

On the following Monday the fan was put back to work with the following results:

9:00-10:00 A. M.	155
10:00-10:55 A. M.	154
11:00-11:50 A. M.	148
2:00- 3:00 P. M.	166
3:00- 4:00 P. M.	166
4:00- 4:55 P. M.	154

an average per hour of 168½ with the fan as against 128 without the fan, an improvement of 31½ per cent.

The main saving from an installation of this kind is of course in wages, as the same set of men will produce 30 per cent more product than before. The fuel saving, although it must have been considerable as shown by the above calculation, could not be determined, as a number of other furnaces were receiving gas from the same gas house. It can only be correctly ascertained when all the furnaces served from the same gas house are equipped in this manner.

Whilst the above described method takes care of working the furnace with the possibly largest consumption of gas and a correspondingly increased load, it does comparatively little towards increasing the initial temperature ta, which we have found is the other determining factor in increasing the efficiency and reducing the fuel consumption of the furnace. This temperature depends on two factors:

1. The always correct proportion of gas and and combustion air.
2. A thorough and intimate mixture between the two.

The second factor is dependent on the construction of the furnace and can in the majority of cases not be influenced without very considerably changing the furnace ports. But a certain maximum temperature can be obtained in any furnace and frequently in excess of the temperatures actually obtained, or where higher temperatures are not desired, the same temperatures can be maintained with a much smaller expenditure of gas, if the gas and air are supplied in a predetermined relation and if this relation is continuously and automatically maintained.

The required initial temperature for the various kinds of metallurgical furnaces are very different and vary from 1900-2000 deg. F. for hardening furnaces to 4500-4700 deg. F. for open hearth furnaces. These are calculated initial temperatures, as they would be obtained if gas and air were burned in the possibly smallest space without transmitting any heat in statu nascendi by radiation to the surrounding walls, etc. The actual obtainable temperatures are much lower and depend on the pyrometric efficiency of combustion, amounting usually to 68-75 per cent of the calculated.

We are dealing in this case with regenerative and recuperative furnaces only, where the required actual temperatures vary from 2400 to 3200 deg. F. The heating value of the gas and the sensible heat carried by gas and air after pre-heating are factors which we must consider as fixed for any given type of furnace. Whatever they are, gas and air should always be mixed in a relation as near as possible to the theoretical for perfect combustion, and automatically kept there. If the obtained flame temperature is too high a reduction in the gas supply will decrease the pyrometric efficiency and cool the flame. As in metallurgical furnaces, the danger of considerable material losses through scaling has to be countenanced, a reducing flame is generally called for, and to be on the safe side it is customary to work with a considerable excess of gas, a very wasteful proceeding and apt to entirely defeat the primary object of obtaining the highest practical initial temperature, compatible with the temperatures required in the furnace.

There is naturally no possibility to lay down hard and fast rules for all furnaces as to the best proportion between gas and air. There are a good many other factors which have to be considered, such as the minimum volume of products of combustion required, the temperatures which have to be maintained in certain parts of the furnace, which may call for slow combustion with a lingering flame and many other individual conditions, but there cannot be any doubt that there is one and only one best condition where the desired relation of gas and air gives the best all-round results, and that any deviation from this condition will always be to the worse. It is this condition which should always be maintained automatically, no matter how much the gas supply to the furnace changes.

Attempts have been made of late to educate the furnace men to regulate the air supply by hand. Such regulation is, however, not practicable and at best very crude. At most mills it is still customary to work with an entirely open air valve and let the relation between gas and air take care of itself, increasing the gas supply whenever one is in danger of obtaining a highly oxidizing flame.

The Askania gas and air mixing regulator has been designed to automatically maintain this desired relation between gas and combustion air. The illustration No. 2 shows the application of the regulator to a recuperative furnace which receives its combustion air through a special air duct by fan pressure. It will be noticed that an orifice is arranged in the gas supply pipe and that the dynamic pressure, i. e., the difference of pressure before and behind the orifice, is taken off in the customary manner. The air valve in this case is of the slide valve type. The slide forms the air orifice, the differential pressure being taken off in a similar manner.

These two dynamic pressures change in proportion to the quantities of gas and air passing through the orifices. In order to keep the quantities of gas and air in constant relation, it is necessary to keep a constant difference between these two dynamic pressures. This is done in the following manner: The two pairs of differential pressures are first passed through a pressure transformer and reduced to two working pressures. Suppose for instance that the two pressures taken from the gas orifice are 50 and 30 mm, and those taken from the air orifice 30 and 15 mm, then the two transformer pressures are (50 — 30) 20 and (30 — 15) 15 mm. The difference between these two is therefore 5 mm.

For the purpose of obtaining this result the two transformed pressures of 20 and 15 mm are admitted on either side of a diaphragm which divides a contact box into two compartments. This diaphragm is set by a simple screw set for 5 mm in the above assumed case. Assume that a change in the quantity of gas results in a change of the transformed dynamic gas pressure from 20 to 25 mm. The difference, which should be held at 5 mm, is now changed to 10 mm and the diaphragm will make an electric contact. Through a suitable gas relais a motor is actuated which in turn opens a butterfly valve in the air main and admits a correspondingly larger quantity of air until the transformed dynamic air pressure is increased to 20 mm, thus restoring the desired difference of 5 mm. As soon as this is done the contact is broken and the motor is reversed, which is necessary, as naturally the regulation limits will always be a little over-run. In this manner the motor will all the time run 20-30 revolutions in one direction, then reverse and make another 20-30 revolutions in the other direction, major changes being taken care of by a correspondingly increased number of revolutions in the required direction.

A regulator of this kind is also necessary where the gas supply to the furnace is kept constant by special pressure regulation valves, etc. In a regenerative furnace where the chimney effect of the regenerator supplies the air, this amount of air gets smaller and smaller towards the end of the heating period in the same proportion as the regenerator gets cooler. A reduction in the air supply upsets the desired pressure difference of 5 mm in a like manner as if the gas supply had been increased, and will be taken care of by the regulator in exactly the same manner.

The installation shown in illustration No. 2 is the application to a producer gas fired heating furnace. The furnace before the installation was using 42,000 cu. ft. of producer gas per hour. Already four hours after the installation had been started, the gas consumption was reduced to 28,000 cu. ft. per hour, and later on an additional reduction of the gas became necessary, as the flame temperature rose to such an extent that it threatened to destroy the furnace ports and arches.

NEW ANNEALING FURNACE FOR WIRE

New annealing equipment for wire, including a furnace and a carriage for annealing pots has been developed by Michael B. Kelly, president and general manager of the American Steel Co., Pittsburgh, and Hugh J. Scanlon.

The inventors state that the object of their invention is to provide a unit in which the temperature at different parts of the chamber may be properly controlled, causing an efficient application of heat to all parts of the annealing pot. The furnace also is designed to permit a gradual increase in temperature as the material moves from the entrance end of the furnace to a certain point and then a gradual decrease until the material arrives at the discharge end.

The furnace proper and the chamber rest upon a concrete foundation. The floor of the annealing compartment which carries the annealing pot carriages is inclined from the entrance to the discharge end to facilitate the movement of pots. The roof slopes down in either direction from the point where the heating furnace adjoins the annealing chamber. Definite specifications for the furnace proper are not given, it being stated that any suitable design embodying a stoking apparatus and equipped with a motor-driven blower may be used. Heat is supplied to the annealing chamber through connecting ports from the furnace and the products of combustion pass out through a stack situated along side of the charging end.

Breakage of Rolls on Sheet and Tin Mills

A General Discussion on the Warming Up of Rolls for This Type of Mills—Author Explains Why Some Methods in Use Today Are Disastrous.

By W. H. MELANEY

PART II.

CONTINUING the discussion of the probable reasons for the breakage of sheet and tin mill rolls as outlined in the preceding article, the writer will endeavor to present in a logical manner some of the methods in use today for warming up these rolls preparatory to the rolling of sheets, and primarily intended to prevent, so far as possible, their breakage under service conditions.

As previously shown, thin sheets such as are produced on a sheet or tin mill must of necessity be rolled on hot rolls, as due to the thinness of these sheets even when rolled in packs, it would be impossible to keep them up to a temperature that would permit of the proper elongation of the packs, if any external means were used to keep the rolls cool. Besides, the rolls themselves would so rapidly absorb the heat from the pack that nothing short of drenching them with water would prevent their rapid heating anyway.

This would be prohibitive, because whatever means were used to cool the rolls would also cool the sheets. Therefore, we must accept the hot rolls as a necessary evil and see what means we can employ to render this condition least dangerous, at least so far as roll breakage is concerned. The mere fact that rolls are hot (if they are kept within practical limits) does not materially increase the danger of breakage, as they can easily be kept within the critical temperatures of the maximum and minimum strength of cast iron and still do good work.

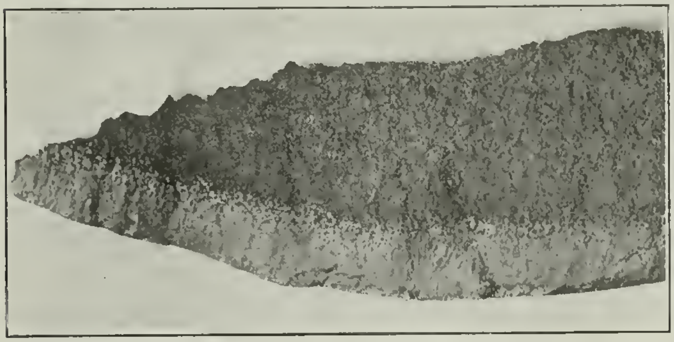

Fig. 1—Chill Roll Structure.

Imparting Heat to the Rolls.

Most of the trouble arises in imparting to the rolls the initial heat required to eliminate the concavity previously turned in them, as the simplest and most practical means of taking care of the puffing up of the center of the roll face which is a natural sequence to the rolling of the red hot packs, the center of the rolling face becoming very much hotter than it is at the ends of the roll.

This is self evident, as in rolling wide sheets (and these are always rolled in the fore part of the week, just as soon as the rolls can be brought up sufficiently full in the center to permit it) the red hot packs are uniformly in contact with the rolling surface over practically its entire face.

The center of the roll has no means of losing any of its heat except by radiation into the surrounding air, while the ends of the roll not only lose heat by radiation, but also by conduction into the necks and wabblers.

The amount of tonnage, that is, the number of packs that are to be put through the rolls in a given time, will determine the amount of concavity that must be turned into the rolls at the start. The greater the number of packs rolled in an hour the less the chance of the roll losing heat from its center by radiation, therefore, the more the concavity must be at the start.

With this explanation of the conditions that always exist on these types of mills, we will take up the manner of imparting to the rolls the initial heat required to bring them into workable condition.

From the description in the previous articles of the vastly different physical characteristics that must exist between the metal on the face of the roll and that of its interior, it follows as a logical conclusion that this initial heat should be permitted to slowly accumulate in order to give the interior of the roll time to warm up sufficiently to take care of the quite rapid expansion of the crystalline face by the greater mass of the granular interior, even though the expansion of the granular mass, inch for inch, is only half as great as the crystalline face. (See illustration of chill roll structure.)

Old Method of Warming Up.

The old time method of warming up the rolls in use for many years, and which, fortunately for everybody concerned, is fast becoming antiquated and generally obsolete, was to warm up the rolls by rolling a certain number of short pieces of sheet bar in the center of the rolls to bring up the center a little until narrow sheets can be produced which will come within the commercial limits of even gauge. As the rolls accumulate heat, the width of the packs is increased until the wider sizes of sheets can be rolled.

By this method of warming up it is apparent that the chilled face of the rolls (starting at the temperature of the surrounding air in which they have reposed for at least a week after being turned) must be very rapidly heated as they come into direct contact with the hot steel.

As a sheet bar is usually only 8 in. wide and as the bar is entered sidewise into the rolls, there will only be a contact of 8 in. in width for a distance across the face of the roll corresponding to the length of the bar being rolled. Of course, due to elongation, this width of contact is increased after each pass, but at best the rolls are only heated in spots from direct contact with the hot steel. Thus, it requires many passes and many revolutions of the rolls before all parts of their rolling face have been in contact with the hot steel.

When, as ofttimes happens, the rougher and catcher get so proficient in entering the bars as to have a stated number of seconds between each pass, then this rhythmical action results in the bar entering at practically the same point on the circumference of the rolls at each pass. This results in a very uneven heating of the roll around its circumference, producing the worst possible condition as regards expansion that could occur, with the chances good for starting a rupture in the face of the rolls that will cause them to break later on.

This is one of the reasons for the statement many times, by the roller, that the roll broke without apparent cause, as the roll had not been abused or in any way misused previous to breaking.

Warming Up With Gas.

The next step in advance was using natural gas in the beginning of the warming up process to at least raise the temperature of the roll above the extremely low point it had acquired in lying idle for a week, especially in the winter time, then following this up with short pieces of red hot bar, as previously explained.

This innovation would have a beneficial effect if the rolls were kept constantly revolving and the gas flame evenly applied all across the face of the roll instead of as was often the case of a single gas flame being projected against the middle of the rolls, causing an uneven expansion of the two rolls.

This method, while having some good features when properly applied, was usually resorted to before the mill crew arrived to take charge of the mill, and being in the hands of men unacquainted with the sensitiveness of chilled rolls to heat conditions, was generally badly abused and probably did more harm than good.

As an illustration of the thoughtlessness with which these things are some times carried out, the writer remembers an instance in which a blow torch was used to quickly heat up a pair of rollers preparatory to placing them in service.

Another illustration was the placing of a cold chilled roll in the winter time on a hot annealing box bottom to partly warm it, with the result that the roll fell in two before ever going to the mill. This was due, of course, to the too rapid and uneven heating of the roll.

Steam Heating.

Later on steam was introduced as the warming up medium, as by this means the rolls could be gradually heated to approximately 150 deg. F., and this heat would extend clear through to the center of the roll and thereby relieve the extreme difference in temperature between the surface of the roll and its interior, before the final warming up with hot bars was attempted.

This was a big step in advance of any previous method, as at no time was there any very rapid heating until the roll had at least become warm all through and the rapid heating of the face of the roll over a cold interior was avoided.

Hot Water Heating.

Then came the most advanced and best system of warming up in use on sheet or tin mills to date, that of hot water heating.

A cold water line is always in service at the sheet or tin stand anyway, as it is necessary to furnish the water used in controlling the temperature of the necks.

Now, if a perforated pipe be suspended across the top of the rolls the same as is used on a balanced roughing mill, and connected to the cold water supply, and then a steam line be connected into the cold water line right at the mill stand, so that by opening a valve the steam is permitted to circulate through the water, then the water can be heated to the boiling point and distributed through the perforated pipe over the whole surface of the roll, the motor being rotated to turn the rolls over the whole time the warming up is taking place and which requires from five to six hours.

By this method the rolls are very slowly and evenly heated from end to end to near the boiling point of water, and this heat extends clear through to the center of the roll, thus putting them in excellent shape to receive the final warming up by rolling crop ends or narrow sheets until the mill is ready to roll the width of sheet desired. Then by limiting the number of pairs that may be rolled by any crew over a given number of hours, changing the limit as the heating up progresses, until about the middle of the week.

By this time a condition is reached where the limit can be removed and the crews permitted to make up during the later part of the week the tonnage that these restrictions prevented in the fore part of the week.

This, as will be seen, does not reduce the output when the whole week's work is considered, but does insure a more careful warming up, the result being less broken rails and a much lower cost per ton of sheets.

Not only do broken rolls raise the cost of rolled sheets per ton to the extent of the money loss on rolls over a given period, but the consequent stoppage of that and other mills driven through it while roll changing is taking place, reduces the tonnage rolled until some times the loss is greater from this cause than that due to the breaking of the roll.

Besides, while the mills are down the heat conditions in the rolls are continually changing and it is necessary to resort to more warming up before the usual width of sheet can be rolled and which is conductive to further breakage of rolls, so it would seem to be the better part of wisdom to prolong the time of warming up the rolls during the fore part of the week, even at the cost of reduced tonnage, because this can always be made up during the later part of the week with very little danger of roll breakage after the rolls have been brought gradually up to their ideal working temperature of from 700 to 750 deg. F.

The next article will deal with the roughing up of the surfaces of sheet and tin mill rolls.

BRIER HILL NOT TO BE IN NEW STEEL MERGER

Reports that the Brier Hill Steel Co., Trumbull Steel Co., and the Steel & Tube Co. of America are to be included in the merger of independents forming the North American Steel Co., have been denied by Thomas L. Chadbourne, New York, counsel for the merging companies. The combine will include only the Republic Iron & Steel Co., Midvale Steel & Ordnance Co. and Inland Steel Co., it is asserted. According to Mr. Chadbourne, progress is being made in closing the merger, although no date has been set for asking stockholders of the respective companies to ratify the terms of the plan. No date is to be fixed until the federal trade commission has given final approval of the terms.

The Trend in Rolling Mill Drives

The Plants Have Become More Extensive and as the Power Requirements Have Increased the Distances Involved Have Outgrown Steam Transmission.

By GORDON FOX*

IN the not distant past steel mills in general had not achieved the magnitude common to many present day plants. Their power demands were moderate The steam engine was available and was the obvious means of main roll drive. Had suitable electric motors been then developed their use would have been questionable. The engines employed for mill drives were comparable in size and economy with those available for power generation. There was then little to justify the use of the electric motor for driving the main rolls.

Today conditions are changed. The plants have become extensive. Their power requirements have increased. The distances involved have outgrown steam transmission. Large turbines and gas engines have been perfected, having economies much higher than mill drive engines. Suitable electric motors have been developed for driving the main rolls. Just as isolated power plants are being generally superseded by central stations, so is power production being concentrated in the steel mill. Electric drive has proven its case. The trend seems unmistakable. It may be of interest to review briefly a few of the considerations which have dictated this trend.

One of the principle factors leading to the general adoption of electric drive is economy of power. It is impossible to set forth general figures which are all inclusive. But they may be used to depict the story.

It might seem that the conversion of mechanical power to electric power in the generator and the later reconversion to mechanical power at the motor, involves extra steps which would prove prohibitive. Such is not the case. The various efficiencies involved are approximately as follows:

	Reversing Mill	Continuous Running Mill
Electric Generator	93	93
Transmission	95	95
Flywheel set	80	..
Train motor	90	90
Conversion efficiency	67	84
Resultant overall efficiency	63	75

The modern steam turbine of 10,000 kw capacity will have an overall economy of 15 lbs. of steam per kw hr. or better, with prevailing load conditions. This corresponds to 10.5 lbs. per brake horse power hour. A reversing drive, with an overall efficiency of 63 per cent, will then require 16.5 lbs. of steam per brake horse power at the mill pinions. A non reversing drive will require about 14 lbs. of steam per brake horse power.

It is rather difficult to establish representative figures for steam drives as data is relatively meager and published results are somewhat at variance. Moreover, results depend upon many factors such as type of equipment and its condition and upon the character of the rolling schedules. However, no injustice is done these engines if the following figures be used:

	Reversing		Non Reversing
	Simple	Compound Cendensing	Condensing
Per I hp hr.	45	30	20
Per B hp hr.	53	36	23

A comparison of the above figures indicates that, with engine drive, the steam requirement is two to three times that of electric drive.

These figures do not tell the whole story. In the case of electric drive we have taken into consideration the transmission losses. With engine drive it is commonly found that the steam consumed at the engine must be increased thirty to fifty per cent to cover transmission and standby losses and the wastage of steam by leaks and incidental uses.

It must be considered also that a given amount of steam can be generated more efficiently in a central boiler plant under fairly uniform load conditions than in scattered boiler houses.

The comparison above is more or less indicative of conditions in the large mill where the central power plant may be of sufficient capacity to warrant the use of large and efficient prime movers. In the small plant the superiority of electric drive from a fuel economy viewpoint is less marked, provided the mill engine is of a modern and economical design. In the smaller mills, however, it will more often be found advisable to purchase electric power from an efficient central station. The small mill often grows. As it becomes larger, the benefits of electric drive usually increase. The initial electrical installation can be well suited to future growth.

Two factors which have exercised a retarding influence on the more general use of central station power are:

Lack of reliability.

Complicated and penalizing rate schedules.

The power plants of public utilities have, as a rule, achieved a high degree of continuity of power but interruptions due to transmission difficulties are still of too frequent occurrence in some instances.

Rate schedules which penalize for a long period because of the occasional peak of short duration impose a hardship which does not seem entirely warranted. Instances arise where a mill cannot be started or an order rolled because of the effect on the maximum demand. These instances lead to loss of revenue both to the steel mill and to the utility. Closer cooperation and a fuller appreciation of mutual interests should eliminate or reduce these differences and bring about the general adoption of electric drive and purchased power in the small mill.

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*Mr. Fox is Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

The more complete the electrification of a large mill, the higher is the total power economy. This results from the use of larger prime movers, from better boiler room practice and from improved load factor. The importance of a high load factor is not fully appreciated. The average steel mill load at its best is of a fluctuating nature. The load factor is commonly on the order of fifty per cent. This means relatively high fixed charges per unit output and also requires the operation of the prime movers at reduced efficiencies. The cost of power can be materially reduced if the load factor can be improved. This can be brought about by careful provision for the minimizing of peaks and by the addition of diversified load. This factor alone is an argument of no small import in favor of the electrification of steel mill yards. In a mill which is extensively electrified the power generating capacity need be only about thirty-three per cent of the connected load.

The advent of the uniflow engine has marked an advance in steam engine drive. But little data is available as to results obtained in mill practice, but it appears that the improvement in overall economy is but a few per cent and, in most cases, does not materially affect the relative status of engine vs. electric drive. Although the engine itself is considerably more efficient than its predecessors, it cannot cause a material reduction in the important items of transmission and standby losses. The steam turbine also has seen marked improvement and, due to its extensive use, there is reason to expect that it will keep pace with or outstrip its competitors.

The economy of the electrically driven mill is not greatly lowered by operation at decreased output, such as may be necessary at intervals. Reduced output has a material influence on the economy of the engine driven mill as the edling and standby losses are relatively high.

The efficiency of the electric generator and the electric motor is practically fixed by the design and this efficiency is closely maintained throughout the life of the apparatus. Through use of flow meters and electrical meters the economy of the prime movers may be subjected to constant close scrutiny. Engines are subject to more or less deterioration and their economy is likely to suffer. It is much more difficult to maintain a check upon their performance and not always feasible to maintain them in most effective condition.

Electric motor drive has proven capable of equalling or surpassing the steam driven mill in the matter of tonnage. There are comparatively few electrically driven mills whose output is restricted by the performance of the main drive motor. Electric drive has proven fully reliable. There have been a few cases where rewinding of the motor has involved several days shut-down. Aside from these instances the delays due to maintenance of electrically driven mills have proven extremely few and of short duration. The cost of maintenance of the electrical equipment is found to be about one-half or one-third of parallel steam engine costs.

The ease and accuracy with which electric power may be metered renders possible the accurate determination of power costs and the proper distribution of expense. With engine drive a more or less arbitrary estimate of power distribution is customary.

The electric meter also assists in the study of rolling methods and pass design and has, in several instances, proven of much value in this respect.

Due largely to the ready means of measurement, data is being rapidly accumulated as to performance of electric drives and it is possible to forecast quite accurately the result to be attained.

The great majority of electric motors applied to driving main rolls have been installed at new mills. It is only of recent date that motors have superseded existing engines. It is most natural that a change from engine drive be made at a time when the engine is badly deteriorated or when the boilers require extensive repairs or when it becomes advisable to supersede the entire mill with more modern equipment. There are no doubt many cases where it will pay to supersede existing engines by motors merely for the sake of economies offered. This will depend upon local conditions, to be sure, and is governed largely by the type of existing equipment. It may be stated in general that it will prove feasible to supersede an existing simple, non condensing engine on a reversing mill by an electric motor. It may or may not be warranted to supersede a compound condensing engine. A blooming mill working to an elongation of ten will likely consume some 1,500 to 2,000 lbs. of steam per ton if driven by a simple, non condensing engine. If a compound condensing engine is used, the consumption will likely be 1,000 to 1,500 lbs. of steam per ton. The electric drive will require perhaps 300 to 400 lbs. of steam per ton of steel rolled.

It is not possible to lay down general rules as to when existing engine drives on non reversing mills should be superseded by motors. Each case deserves individual consideration. It appears, however, that the superior economy and the many incidental advantages of electric motor drive would justify the necessary expenditure in many instances.

The loss of production during the interval necessary to a change over from engine to motor drive may, in some instances, be a serious deterrent. The recent accomplishment at Steelton, Pa., in which a complete electric reversing drive for a forty inch blooming mill was installed in twenty-three days, shows what can be done when necessary.

The practice in main roll motor drives appears, in itself, to exhibit a trend. Perhaps the most marked factor is the growing popularity of the adjustable speed drive. The added convenience as well as the increased production gained through adjustable speed provision has given impetus to the adoption of this type of equipment.

There appears to be a tendency toward the more extensive use of direct current motors for main roll drives. In some cases this practice has been dictated by the requirement of very close speed regulation or by the desire for rapid speed adjustment. However, even where no special requirements exist, the direct current motor is being proposed for the smaller drives but in larger sizes than heretofore.

A new type of adjustable speed set, the frequency converter system, now has two installations to its credit. This system appears meritorious and increased popularity is probable.

The high speed motor or set, driving through reduction gearing, appears to be gaining in favor. The principle benefits are: lower first cost of electrical equipment; higher efficiency and power factor. These benefits are particularly marked in the case of sixty cycle apparatus. The increasing use of this frequency is no doubt a factor encouraging the use of higher speed motors. The popularity of the adjustable speed drive is also a contributing factor as the first cost of many of these equipments is decidedly influenced by the speed selected.

Hydraulic drives continue in use but their field is being gradually usurped by the electric motor. The disadvantages of hydraulic drive are low efficiency, high maintenance, inconvenient control, freezing and danger from molten metal. Hydraulic mechanisms are well adapted to show linear motions. The electric motor is essentially a high speed rotary device and must utilize screws, racks, cranks, and perhaps several gear reductions to convert to slow linear movements.

Hydraulic cylinders have a distinct field for balancing rolls and lifting tables, a field which the motor cannot displace. Hydraulic drive has a distinct advantage as applied to shears in that the torque is quite definitely restricted. A shear equipped with motor drive and flywheel is subject to breakage or perhaps a bent shaft if cold metal is cut, since protection cannot be afforded against the stored energy in the flywheel.

Hydraulic drives also continue in use to some extent due to their prior development. In some cases it may not pay to redesign a machine for motor drive due to the small demand and the development expense. In this class may be mentioned the revolving jib type ladle crane used in some Bessemer plants.

Roberts Ovens Successfully Coke Illinois Coals

The Coking of Illinois Coals With Special Reference to the Plant of the St. Louis Coke & Chemical Company

By H. V. PATTERSON, Engineer
American Coke and Chemical Company

THE steel industry has been called the backbone of the country, but inasmuch as the reduction of the original iron ore cannot be economically accomplished without the aid of coke, the coke industry may be called the spinal cord that runs through the backbone. The developments in the coking art are of paramount interest to the men who are engaged in the manufacture of iron and steel for new and better ways of making coke mean a reduction in the cost of pig iron, and this in turn is reflected in the cost of the finished steel.

The requirements for a good blast furnace fuel are so stringent that heretofore only the best coking coals of the United States have been available for the manufacture of coke that is to be used in the furnace. The plentiful supply of such coals and their close proximity to the centers producing iron are in some measure responsible for the lack of development of methods for coking the coals that are low in the constituents that are considered necessary to form a good metallurgical coke. The coke oven designers have, therefore, been satisfied to improve minor details of their ovens and the auxiliaries, but have in the main adhered to their original designs in the flues and walls and the application of heat to the coal.

The operators have been satisfied with these designs, which have generally been foreign developments adapted to American practice, because nothing better was offered. They have studied the various types of flue ovens offered and have tried to improve them, but it is generally conceded that the types now offered have about reached their zenith and that further improvements will be minor in importance. These types have all been of vast importance in the development of the coking art in this country and therefore have been of importance to the steel industry, but like all things they have had their day and now must make way for a better type that has a broader application.

It seems to be a truism that as our natural resources begin to wane in quantity, methods of using other resources, that heretofore were considered unusable, will always be found. This is now true of the coals of this country. The good coking coals are rapidly becoming exhausted and it becomes necessary to utilize the fields that produce the feebly coking coals. The deposits of such coals are enormous and will be available for many years to come. The principle deposits of such coals that are now being worked occur in Illinois and Indiana though many states further west contain large deposits of coal that are considered to be out of the coking class.

In addition to the gradual disappearance of the coking coals, the steel industry has extended westward and the increasing freight rates have made it necessary to find a means of utilizing the coals that are close to the points at which the iron is made. It has, therefore, been apparent for some years to those with a vision of the future that a means of using the so-called non-coking coals must be developed, and the engineers concerned in the design of the Roberts oven started their work with the main idea of developing an oven that would utilize these coals and therefore make available the large resources that would otherwise be useless except as a domestic or boiler house fuel.

After a number of years' patient work and the expenditure of large sums of money, the efforts of these engineers have been crowned with success and the plant of the St. Louis Coke & Chemical Company at Granite City, Ill., is a monument to their perseverance in the face of apparently unsurmountable obstacles. The results obtained at this plant have been even better than they had hoped and it is now an assured fact that the non-coking coal fields are open to development with an assured outlet for their product and the steel industry is no longer dependent on the rapidly disappearing deposits of coking coals in the east. In addition to the opening of the heretofore unused coal fields of the west, it is also now possible to utilize many coals from the eastern deposits that have never been considered available for the manufacture of metallurgical coke.

It is unnecessary here to go into the history of the development of coke ovens in general or the many designs of the Roberts oven that were made and discarded. It will be sufficient to describe the ovens as installed at Granite City and mention the results that have been obtained at that plant when working on 100 per cent Illinois so-called non-coking coals. It may be mentioned, however, that since some of the results at this plant have become known, many others have claimed to have coked there same coals, but none of these claims has been substantiated by continuous operation. It may be safely said that the Granite City plant is the only plant in this country working continuously on the Illinois coals and producing from them a coke that not only makes an ideal metallurgical coke, but that the blast furnace at that plant, when using this coke, has made a record that has yet to be equalled by any furnace in this country. The Granite City plant is not performing stunts with one or two charges of coal, but is daily producing coke from the Illinois coals and this coke is the only fuel used in the 19,000 cu. ft. furnace which is operated in connection with the coke ovens.

The plant of the St. Louis Coke & Chemical Company is located at Granite City, Ill., and is laid out for an ultimate capacity of 3,000 tons of pig iron per day. The coke oven department is designed for 320 ovens with a capacity of 9,600 tons of coal. The first units are 80 ovens with a capacity of 2,400 tons per day and one blast furnace producing 500 tons of pig iron per day.

The coke oven plant designed by the American Coke & Chemical Company has no radical departures from the usual equipment used in such plants, and as there are many descriptions of such plants it is unnecessary to go into detail. The coal is brought in by rail and unloaded by means of a car dumper. It is taken from the transfer car either to stock or to the hoppers from which it is delivered to the crusher. From these it is taken to the hammer mills and then to the storage bin.

The charging of the ovens is by an overhead larry with five hoppers; leveling and pushing is accomplished in the standard way. The gas is carried off through one ascension pipe to duplex collecting mains from which it is taken in foul gas mains to the coolers.

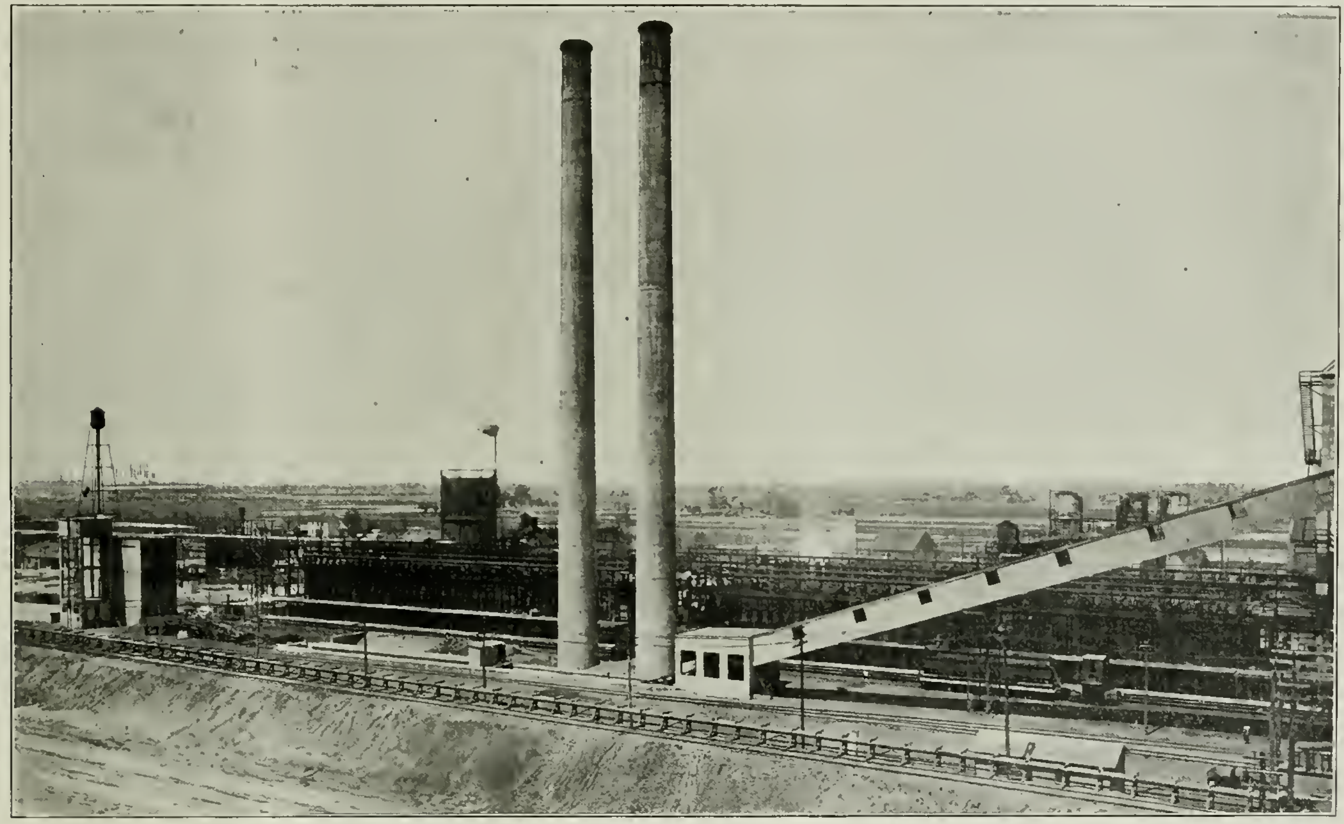

Fig. 1—General view, eighty Roberts Ovens, Granite City, Ill.

The by-products department is divided, the exhauster room and pump room being under one roof, but divided by walls, and the ammonia house being housed separately. After leaving the ammonia house, the gas is treated for light oils and the light oil equipment is located adjacent to the ammonia house, but not directly connected.

The rich gas is sold to nearby industrial plants and part of it is pumped about five miles to the East St. Louis Gas Company. This gas will run about 590 Btu. The lean gas is, of course, used for heating the battery. The heat value of the lean gas is about 517.

As it is the ovens that produce the coke, the readers of The Blast Furnace and Steel Plant will be more interested in a description of them than in further particulars regarding the auxiliaries.

The Roberts ovens as installed at this plant are of the recuperative type and are illustrated in the cuts accompanying this article. The gas for combustion is carried in the main battery header which occupies a position on the coke side similar to the collecting main on the pusher side. From this header the burner headers are taken through manifolds which are equipped with shut-off cocks.

The burner headers are of cast iron and are two compartment, one side carrying the primary gas and the other side carrying the secondary gas. These headers are square in cross section and the top is, therefore, flat and as the spaces between the headers is filled in, the top of the battery is smooth and readily kept clean. This is illustrated in the cut (Fig. 3).

The gas for the individual burners is taken from the sides of the headers through a shut-off cock specially designed for this purpose. It is by means of these cocks and the disks set in the header manifolds that the close regulation of the oven is attained.

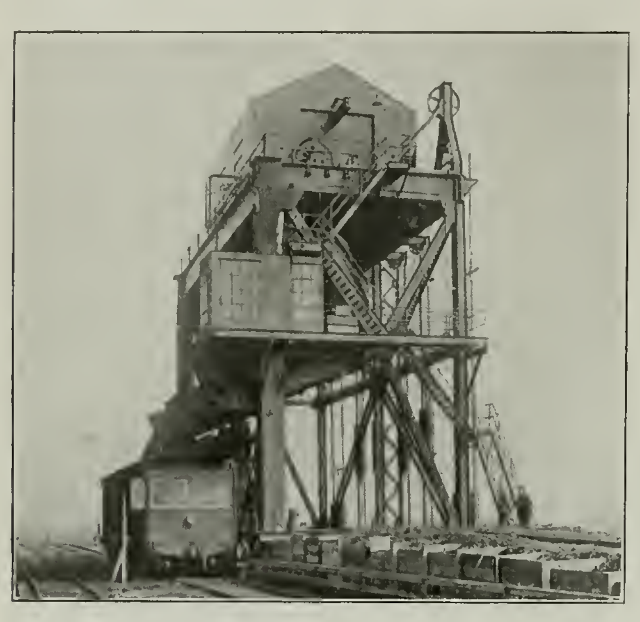

Fig. 2—View of Car Dumper.

The core of the cock is of cast iron and each core is drilled with a hole that is graduated in size from the pusher size of the oven to the coke side. The reason for this graduation is the taper of the oven. The taper or widening of the oven causes a larger charge of coal on the coke side than on the pusher side. This increase in charge is gradual as the taper is uniform. It is in all ovens necessary to burn more gas towards the coke side than is used on the pusher side if the charge is to be uniformly coked in the same length of time. Compensation for this increased charge is difficult, if not impossible, in any type of oven using but a few points for the introduction of the gas or using nozzles made of a material that does not lend itself to accurate calibration.

In the Granite City ovens, the core of the cock, being of cast iron and always being at atmospheric temperature, is readily drilled to a very accurate size and it will maintain this size under all operating conditions. There are 24 primary burners on each side of the oven and the holes for the gas are drilled with an increasing size from the pusher side to the coke side. This increase is in exact proportion to the increase in the coal charge in the portion of the oven served by that burner. This means that the proportioning of the gas is accomplished every 21 inches throughout the length of the oven. The same exact control is used on the 24 secondary burners for each side of the oven.

The proportion of the primary and secondary gas is attained in the same way by the use of disks set in the manifolds supplying the headers. These disks are drilled with accurately calibrated holes through which the gas passes. As the quantity of gas passed by an orifice is proportional to the size of the opening and the pressure, the openings in the manifold disks and those in the cores of the cocks will always pass the desired quantity necessary for the coking of the charge in the desired time. To change the coking time it is only necessary to change the main pressures on the battery and each header and each cock will perform its duty without further attention.

The primary gas is admitted at a point about 16 inches below the top of the coal charge. At this point it meets the preheated air from the recuperators and combustion starts. The air is under control with the same accuracy as the gas, as there is a slide brick which regulates the flow of the air through the air ports. The quantity of air admitted through these ports is sufficient for the combustion of both the primary and secondary gas. The primary gas, therefore, meets 100 per cent excess air for its own combustion, for the primary gas is approximately one-half the total gas burned.

The initial combustion of the primary gas takes place in a short mixing duct where the small amount of radiant heat is extracted. As this gas meets a large excess of air, the flame temperature is subdued and as both gas and air are admitted at a neutral pressure, the combustion is carried on quietly and without the intense generation of heat that is noticed in other types of ovens.

Immediately below the mixing chamber is the typical staggered wall construction used in the Roberts oven. Here the stream of burning gas and air is divided into three parts by the wall brick, and from this point to the bottom of the wall the burning gases have a gentle wave motion that thoroughly mixes them and by impingement on the body of the wall brick the heat is efficiently and uniformly extracted.

The secondary gas is admitted about half way down the wall at a point where the primary gas will no longer produce sufficient heat to carry on the coking of the charge in the bottom of the oven. This secondary gas is admitted into an atmosphere of inerts from the primary combustion and these so dilute the oxygen present that combustion proceeds quietly and uniformly. This portion of the wall is identical with the upper portion and as the wall bricks are practically entirely surrounded by the burning gases the extraction of heat from them is continued with the same high efficiency.

After leaving the wall, the waste gases from the two sides are combined in one flue that passes under the sole of the oven. By this method, sufficient heat is produced to coke the sole of the oven in a vertical direction. This produces an ideal surface on the bottom of the charge for pushing. From the sole flue the waste gases pass into the recuperator which is composed of flues for the passages of the waste gases and around which passes the air that is to be preheated. After leaving the recuperators, the air passes up through ducts left in the separating wall that occurs between each oven.

The waste gases pass from the recuperator into an offtake that connects to the main waste gas flue and thence to the stack. The offtakes are provided with butterfly valves that control the draft to each oven. In addition to this valve there are slide dampers in each sole flue that aid in maintaining the proper distribution of draft through the oven walls.

The air is carried to each oven through a series of six tunnels that are incorporated in the concrete pad under the battery. By using this method of air introduction, the concrete pad is maintained at approximately atmospheric temperature and can never become overheated, expanded and cracked, a condition that has harmed many batteries heretofore built.

The entire operation of the ovens is extremely simple and unless there is a radical change in coking time the daily attention of the heater is confined to observance of the main pressures and as these are under control by governors there is very little for the heater to do. If the coking time is not changed, the heater merely raises or lowers the main pressures to admit the required amount of gas for the coking time decided upon and the oven will quickly respond and continue to function with the same efficiency on the new coking time.

It is not within the province of this paper to go into the coking qualities of the different coals or discuss the properties that make a coking coal. It is sufficient to state that the designers of this oven have studied the action of the various coals and formed the opinion that the low grade coals of Illinois could be successfully coked if the heat was applied rapidly and uniformly throughout the charge in the oven. That their theories were in part correct is evidenced by the results obtained in the Granite City plant which has now been operating for over a year and a half on the coals from Illinois and from them is making a coke of such superior quality that the blast furnace is breaking all previous records for sustained operation with the minimum of coke per ton of iron produced.

The application of heat in the Roberts oven is uniform throughout the entire wall. There is but one shape in the main heating wall and this one brick forms both sides of the heating chamber. This brick is best described as a solid brick with the sides and top so cut away that when two or more are laid together there is a space for the passage of the burning gases between the ends which are left the size of the original block. This is readily understood from the drawings. The brick are so laid in the wall that the spaces in one tier are directly over the center of a brick in the tier below. This gives the gases a wave motion as they pass downward in the wall and the intimate mixture of the combustibles is assured by this wave motion and the impingement on the necks of the brick.

The ends which form the sides of the combustion space are but three inches thick and there is, therefore, but three inches of brick interposed between the burning gases and the coal charge. The center portions of the brick, however, form a series of studs that give to the wall the strength of a solid structure. The wall is, therefore, at once the thinnest and the strongest that has ever been designed.

Another factor that adds to the efficiency of the heating is the large surface exposed to the heating gases. This surface is two and one-half times the area of the surface disposing the heat to the coal charge. The result is that the transmission of heat to the coal is carried on at a very rapid rate and as all parts of the walls are uniform in construction, this distribution of heat will be uniform throughout the entire wall. The gases introduced at the primary and secondary burners are also accurately proportioned and this in connection with the continuous flow of the combustibles in one direction without reversing or cessation for any cause, forms the most efficient and uniform heating medium ever developed for carbonizing coal. This has all aided in solving the much desired coking of the low grade coals from Illinois and other states.

The normal charge in the ovens as installed at Granite City is 15 tons, and this charge has been coked in as low as 12 hours over continuous periods. This gives a capacity per oven per day of 30 tons, the largest that is known today. The coking time of the ovens has been varied from this up to 24 or more hours with the same results—a perfect metallurgical coke. The coking time has also been changed as much as four hours within a period of 36 hours and it is not known that any other oven will show this flexibility without injury to the walls. The Roberts wall is so keyed together and is so strongly built that great variations in temperature are met without difficulty.

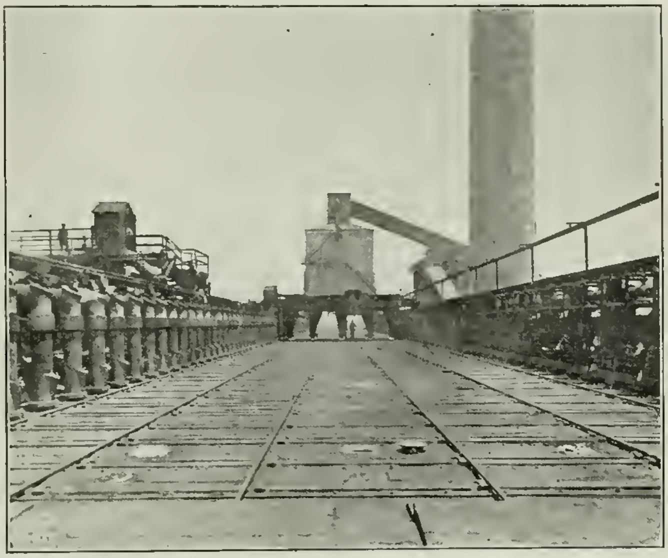

Fig. 3—View of tops of 80 Roberts Ovens, Granite City, Ill.

The average analysis of the coals used during two months of this year are as follows:

Moisture	8.06%
Volatile	34.51
Ash	9.35
Sulphur	1.38

The coke averaged—

Moisture	4.44%
Volatile	2.47
Ash	13.06
Sulphur	1.13

The yield of coke has been well over 70 per cent and the loss from breeze has averaged about 3.4 per cent. This is interesting as showing the high grade of coke produced in this oven, as it has generally been found that the high volatile coals when coked in other ovens produced a large percentage of breeze.

The tar has been about 8 gallons; ammonia, as sulphate, 25 to 28 pounds. The gas yield has averaged 10,250 cu. ft. with a heating value of 595 for the rich and 517 for the lean. The quality of the by-products from the Illinois coals is comparable to that from other coals. The yield of gas is perhaps not as high as might be expected from the volatile matter in the coal, but this is true of many of the high volatile coals that are within the reach of other systems of coking.

There is another interesting point that is well known to those who have experimented with the Illinois coals and that is the quantity of heat necessary to coke them. It is always found that the addition of Illinois coals to a mixture will at once run up the quantity of fuel gas. It is an inherent quality of this coal that it requires more heat to form it into coke than do the strongly coking coals from the eastern states. It naturally follows that those who use the Illinois coals will produce a lower quantity of surplus gas.

This was well illustrated in a plant during the war when they were compelled to use Illinois coal, as the eastern coals were not available during that period. This plant has two well known systems of ovens and as they operate as a gas company they were compelled to make gas. They used Illinois coals and succeeded in driving off the volatile matter from the coal, but did not make any saleable coke. They at once found that the production of gas was comparable to that from the eastern coals, but that an exceptionally large percentage of this gas was required to heat the ovens. As they had been operating on the eastern coals for some years, the opportunity for comparison was admirable. They were very glad to be able to return to the eastern coals at the end of the war. However, the high heats necessary in the attempt to use the Illinois coals in those types of ovens practically destroyed them and they have since turned to water gas as a solution of their difficulties.

Part of the coke made at the Granite City plant is used in the blast furnace and part is sold for various industrial purposes and for domestic use. The yield of furnace coke is very high and the quality of the coke is so exceptional that furnace operators who have watched the operation of the furnace declare it to be the finest fuel they have ever seen.

The furnace is 19,000 cu. ft. capacity and was designed by Freyn, Brassert & Company of Chicago. It has been in operation for the same length of time as the ovens except for a short period last year when it was banked. The furnace has operated over extended periods (two months or more) with a production of 515 tons of pig iron per day with the consumption of only 1785 pounds of coke per ton of iron produced. A high percentage of the ores used are very refractory and yet the top temperature runs as low as 264 deg. F. The flue dust has been less than 90 pounds, and hanging and slipping are almost unknown, due to the fact that the zone of fusion is confined to the bosh of the furnace instead of extending upward into the shaft. It is remarkable to look in the tuyeres of the furnace and see the coke flying around amid the drops of melted iron.

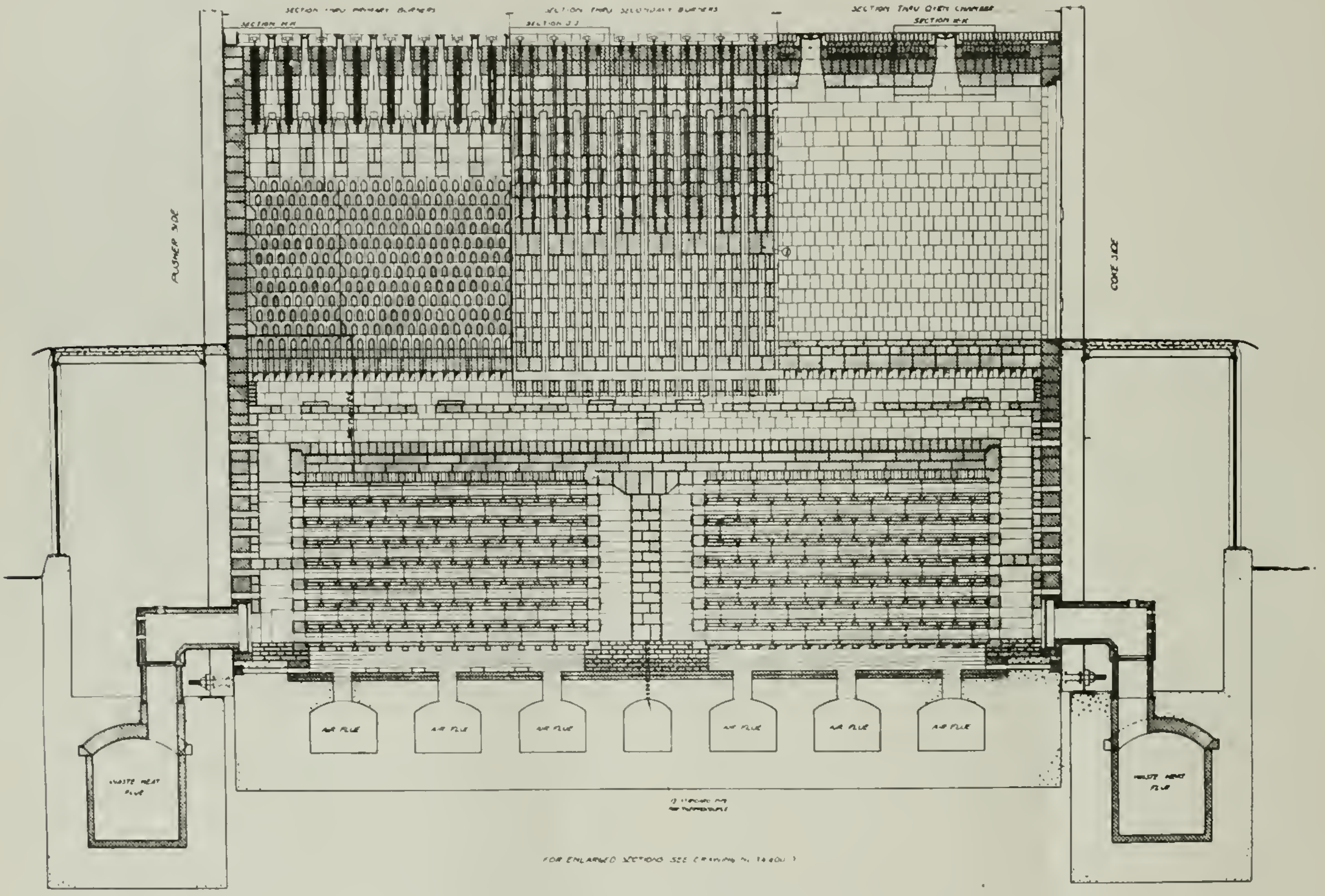

Fig. 4—Longitudinal Section through oven.

The analysis of the furnace gas is about as follows and is evidence of fuel economy:

CO_2	14.1%
CO	24.3
H_2	3.2
CH_4	.2
N_2	58.0
Ratio $\frac{CO}{CO_2}$	1.72
Btu.	92

The furnace superintendent has admirably summed up the superior qualities of the coke produced by the Roberts oven from the Illinois coals as follows:

1. Absence of cross fracture, combined with uniformity of size.
2. Uniformity of cell structure.
3. Tough cell structure, permitting a heavy burden.
4. High speed of combustion—approaching that of charcoal.
5. Concentration of heat of combustion in hearth, where it can be used most economically.
6. Low transfer of hearth heat to shaft.
7. Low top temperature—longer contact of the ore with reducing gas, which means maximum stack efficiency.
8. Lean waste gas analysis, low thermal loss.
9. Low flue dust loss—more regular settling and lower gas velocity.
10. High production with low fuel consumption.

The proof of the results of the Roberts ovens is in the furnace which is operating on the coke produced in those ovens. There has been something done that was not done before, and an outlet for the Illinois coals has been provided and the steel industry has been aided, for it is now possible to use coal that is produced near some of the large steel plants located in the west.

While this discussion has been entirely on the results produced from the Roberts ovens when operating on Illinois coals, it is well to state that they have also been operated on some of the high volatile coals from Pennsylvania. The results when using the eastern coals were what might be expected. The coking time was lowered without burning any more gas, showing that the eastern coals require less gas to form them into coke than do the Illinois coals. The coke was extremely uniform in size and the percentage of breeze and small sizes was unusually small. This is not surprising, for an oven that will produce such high results from the feebly coking coals would be expected to do much better on the well known coking coals.

The summary of this is:

That a new method of coking coals has been developed that will produce more and better coke than any of the older systems.

That the production capacity, per dollar invested, is higher than any other system.

That the operating costs of both ovens and blast furnaces may be reduced; and finally,

That a new field of coals that heretofore could not be used have now been made available to the steel industry, and furnaces will be assured of a higher grade of fuel than they have ever used.

The Manufacture of Light Steel Castings

Discussion Covering the Practical Experiences of the Author in a General Jobbing Steel Foundry Where Castings from a Few Ounces Up to Fourteen Tons in the Rough Are Made.

By H. BRADLEY*

IN this paper, which has reference to the practice of light steel castings, any reference to academic or laboratory practice has been purposely omitted. It is dealt with from the author's practical experience of a general jobbing steel foundry, making all classes of steel castings from a few ounces up to 14 tons in the rough, and with metal of carbon content varying from 0.08 to 1 per cent and over, and additionally in chrome and manganese steels.

The Plan of the Foundry.

To run a foundry successfully, the largest output with the minimum amount of handling must be attained. To carry out this successfully, the shop should be planned for the pattern to enter at one end (where there should be shelves or pockets to receive it) and the core boxes with card attached, with works order number, description, and quantity off. The card is ruled at back, so that each day's cast may be entered thereon. When the pattern and core boxes are given to the molder the card should have the man's check number marked on, together with the date.

When possible there should be a separate bay for dry sand molds. The work for dry sand should be commenced at the end of the shop, then carried down to the drying ovens, then to the closing and casting floor, where the molds should be arranged in straight lines, and all runner bushes should be as near one height as possible, so as to avoid hoisting or lowering the ladle. The steel plant should then be fixed as near as convenient, utilizing the floor nearest to it for the green-sand molds, as these are generally of the lightest section of castings, and, therefore require the steel when in its most fluid state, to avoid short or faint-run castings.

When the steel is a little on the stiff side it can be used for the thicker section castings. The boxes, after casting, should then pass on a little further to be knocked out and examined, and a note taken of the good and defective castings and recorded on the back of the abovementioned card. When the job is completed the card should then be handed in to the foundry office, the castings going forward to the cleaning or dressing shop, which should be at right angles to the molding shop, with tram lines running from one to the other.

The fettling or dressing shop should be equipped with shot-blast plant, oxy-acetylene burning plant, and both circular and band saws, according to size and class of work and output. The catsings should then go to the machine shop and dispatch shed.

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*Institution of British Foundrymen, Birmingham Conference, 1922.

The Making of Castings.

The first thing to consider is the pattern making, which depends, firstly, on the quantities of castings required from each. A good wood pattern will withstand the making of 500 castings from it, either by hand or machine. If repetition work is carried out, then either brass or white-metal patterns are necessary, which should be on the machine for small castings. The author prefers the hydraulic machine for boxes up to 24 in. round or square, and for deep-lift patterns the roll-over machine. For anything over 24 in. the jarring machine can be used to better advantage.

The difference in making a pattern for machine molding and hand molding is that it is always necessary to fix coreprints to the pattern for the former under any parts that are undercut, as the sand is jarring downwards, therefore, it naturally falls away from the underside of any projecting part.

Tackle—The boxes should be strong, light, and made of steel. They should all be interchangeable according to the various sizes either for hand or machine. The double lug box is best, giving a truer alignment. The double lug can be either a slot and hole or two holes.

For patterns with small quantities off and intricate joint, a plaster oddside should be made, as they are easy, cheap, and durable.

For large orders or repetition work, machines are a necessity. They do good in two ways, i. e., by reducing costs, and increasing output on the jobs they are working. They also speed the work up generally in the shop. Two boys working a machine with boxes 10 in. by 10 in. by 4½ in. have produced 180 complete molds in the day with from two to four cores in each. Two youths, 17 to 18 years of age, have produced 62 molds, 18½ in. high by 16 in. by 5 in. deep, painted and blacked. The quantities vary according to size of boxes and design of castings. To get the full advantage from the larger machine it is essential there should be an electric crane specially for its use.

For large quantities of light castings the Tropenas vessel or electric furnace are to be recommended.

To insure sound steel castings it is essential to have in the first place a good steel, that is, steel containing the correct composition for the work required, and properly "killed," in order to ensure it lying quietly in the mold. It is also essential that the sand be suitable; if being used green, it should have just the correct moisture, and just sufficient bond to work it. Sand, in the first place, should always be dried before milling in order to get the required moisture by adding water, and the necessary binding material. The author prefers to use the natural sands whenever possible. The sands generally used in England for steel castings are Belgian loam, used either by itself or with a small amount of silver sand, cornish loam with silver sand, and Yorkshire sand with silver sand. Of the three mentioned, the author prefers Yorkshire, as it is easy to work, is tough, but not too close, gives a good skin on either dry or green-molded castings, and does not cake in the mill as much as the first two. For cores, the author's practice is to mix eight parts of silica to one of Yorkshire and up to 4 to 1 for molds, varying, of course, according to weight and design.

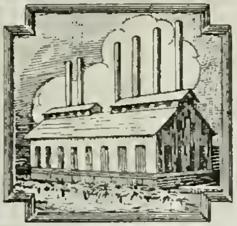
Running and Feeding.

Where possible the best system is bottom runners, and in one of the thinner sections of the casting. Careful judgment is required for feeding heads to have the required size and in the right place in order to get a solid casting and avoid wasting steel.

Very soon after casting all runners and feeding heads should be released so as to enable the contraction to take place and avoid having a pull in the casting.

When the pattern is made, it should in the first place be taken into consideration as to whether the casting is to be made green or dry, and the decision generally arrived at is based on how much machining is to be done on the casting, and whether the difference in the two methods of molding is worth the risk of making an unsound casting by making it in green sand. A further consideration depends upon design of the casting. In such cases it is essential to make it green to allow for the contraction strains taking place and preventing the casting pulling into pieces. In some cases the weight and design must be taken into consideration in deciding these points. If there is no danger of the casting pulling with a dry-sand mold owing to design, it is always safer to produce a sound casting from dry-sand work than from green-sand work, owing to the properties of the steel used for casting. Of course, there are many different designs of castings to be contended with, and the greatest trouble given to a steel foundry manager is often caused by the designer not having had any steel foundry practice. To produce good, sound steel castings it should always be the aim to have the thicknesses of the metal as much alike as possible. Wherever thick or bulky pieces of steel are joined together with lighter sections, means have always to be found (if the design cannot be altered) to overcome the difficulties encountered. This can be achieved, either by using chills or causing the thick portion to freeze approximately at the same time as the thinner sections. In some cases, however, a reinforcement is used, but this is not always a wise policy, owing to the possibility of a mishap, after the casting is put to work, disclosing the reinforcement in any fracture. Naturally, the blame would straightaway be put down to this method. This can be further illustrated by a large mill pinion casting of, say, 2 ft. 6 in. tooth face by 3 ft. diameter in the tooth portion, reduced down to, say, 18 in. or so on the neck portion. The best method of producing this class of casting is to have it cored out. At times, however, it is found that engineers object to this method of coring out. They state they must have a solid casting. In order to meet their views, as far as possible (which steel founders, of course, have to do), it is endeavored to produce a solid casting. This, however, is an impossibility without some method of reinforcement, as it is impossible to feed the body portion of the casting of the dimensions mentioned, through the size of the neck and the wobbler. Therefore, the method of reinforcement has to be used. This is accomplished by putting in what is called locally, a "dummy," sufficiently large to prevent the pipe right through the top neck and wobbler, which would take place unless something of this description was carried out.

Again in the case of hydraulic cylinders, in most steel foundries, there does not seem to be any set way in which to cast them. This is done, either mouth downwards or upwards, but in any case there should be taken into consideration the location of the large bulk of the steel and the best means of feeding it. As will be realized, it is necessary to feed all steel castings from the head. In iron foundries, a wrought iron, or mild steel feeding rod is used, and small shanks of metal are poured in time after time until it is set. This method cannot be adopted in a steel foundry, as it would pull out the steel instead of causing ti to become more solid as in the case of iron castings.



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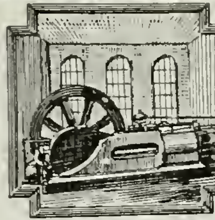

Fire Hazards in Plants Using Pulverized Coal

The Writer Cites Various Cases Where Fires and Explosions Originated from the Improper Handling of Pulverized Coal—Many Hazards Connected to the Apparatus Used for Pulverizing.

By L. D. TRACY*
Coal Mining Engineer, U. S. Bureau of Mines

SOME one has said that the best way to fight fires is to prevent them, and it is along the line of fire prevention rather than fire fighting that this paper has to deal, for, after all, a fire in a building in which pulverized coal is being used is not fought differently than a fire under similar circumstances, but omitting the coal dust. There are perhaps one or two additional dangers which will be mentioned later.

The hazard in pulverized coal lies in its ability to start trouble so that the principal function of the heads of a fire department in that connection would seem to be to rigidly inspect plants in which this type of fuel is used and to impress upon the owners and operating force the absolute necessity of keeping to the minimum, conditions which would tend to cause and ignite a cloud of coal dust.

It will be noticed that the term "cloud of coal dust" is used. Pulverized coal in bulk is not especially hazardous but as soon as it is raised into a cloud and mixed with air it becomes as dangerous as an unconfined body of gas.

It takes only a small quantity of coal dust per cubic foot of air to cause a very explosive mixture. In tests by the Bureau of Mines a mixture of 0.032 of an ounce of Pittsburgh Coal dust per cubic foot of air has been sufficient to cause an explosion when brought in contact with a flame. Perhaps this can be better understood when it is realized that all that is needed to produce such an explosion is the amount of coal dust that can be held on a silver quarter of a dollar mixed with the air contained in a 12 in. x 12 in. x 12 in. box and this mixture brought in contact with an open light.

As an illustration of what such a combination of dust cloud and open lights may do, the fire in a coal crushing plant connected with one of the steel mills in the Pittsburgh District may be cited. This was a very simple plant used for crushing lump coal for automatic stokers at the boiler plants. The coal was dumped from the railroad cars into a small hopper which fed by gravity into the crusher. From the crusher the coal dropped through a chute to the foot of an elevator by which it was elevated to a small bin, from whence it was delivered to railroad cars on a track depressed some 20 feet below the upper tracks. The elevator was partly closed on three sides, but at the foot it was open on the side toward the depressed track.

As the coal was dry a cloud of dust surrounded the plant during the crushing operation.

Early one morning the chutes became clogged compelling the crusher to shut down. Half an hour later five men went to the foot of the elevator to clean the chute. For lighting the elevator shaft, when such clogging occurs, there are two incandescent lamps, attached to a wooden cross-pipe and connected by a flexible rubber covered wire, to the regular lighting circuit on the platform. These lights were lowered when the men went below the platform, but to provide additional light, one of them carried a lighted torch; a strong wind was blowing which extinguished the torch light.

It was stated that the last man could barely have reached the bottom of the elevator when there was a burst of flame which killed three men, badly burning a fourth who died a few hours later at the hospital and painfully burning a fifth, who recovered. The cause of this accident was supposed to have been the lighting of a match in order to relight the torch and by doing so ignited the dust cloud at the foot of the elevator.

About a year ago the writer was requested by the officials of one of the largest steel companies in Pittsburgh to look over part of the plant handling the coal for their by-product ovens. The buildings were of inflammable construction and covered with fine coal dust and as a result of this inspection the Bureau invited a number of the Foremen of the mill to the Experimental Mine of the Bureau to witness a demonstration of the inflammability of powdered coal. A large funnel was connected to a compressed air line and a short distance away a piece of burning waste was placed on a small rod driven into the ground. The air was turned on, raising the coal dust into a cloud which was blown across the burning waste.

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*Published by permission of Director of U. S. Bureau of Mines.

Another form of coal dust which is exceedingly dangerous and to which perhaps too little attention is paid is the dust coming from small heating furnaces in which pulverized coal is used as fuel. These furnaces are comparatively small and are used principally to heat bars and rods for small forgings, nuts, bolts, etc. They are somewhat like the old style blacksmith forge, having, generally, a hood over the fire to carry away the fumes. The pulverized coal is shot in under pressure and sometimes all of it is not completely burned and goes off into the surrounding atmosphere as floating dust which finally settles all over the platforms around the furnaces, the beams and girders of the buildings and any other place upon which it can lodge.

The writer made an investigation of a plant in which this condition existed and found this kind of dust all over the building. Samples were taken and analyzed. Many of these samples were not much different than a poor grade of pure coal.

Now as to the effects of such dust when looked upon from the viewpoint of a fire hazard. Let us take the case of a fire at the Burden Iron Works, Troy, N. Y. This plant contained about 80 puddling furnaces about one-fourth of which were using powdered coal as fuel. In front of each puddling furnace was a one-ton steel bin which was filled with powdered coal by means of a screw conveyor. From the bottom of the hopper the pulverized fuel dropped into a small screw conveyor by which it was fed into the burner.

The building proper was of ordinary mill construction with heavy wooden trusses. It was stated that these trusses were thickly covered with dust, as the flat surfaces were of comparately large area.

On the night of the fire the coal dust was leaking in small quantities from one of these bins and falling on the floor. All the doors in the side walls of the building were open and puffs of wind blew little clouds of coal dust in front of the furnace. As the operator was pulling a heat, some of this dust came in contact with the hot slag and was immediately ignited. Instantly there was a flash and the resulting flame reached up into the roof trusses. So quickly did the whole roof become ablaze, that the men had to drop their tools and run for their lives.

A rather peculiar accident happened in one of the Pittsburgh steel mills. At one point in the building was an electric switch so situated that dust could settle between the poles. One Sunday when the mill was shut down, sufficient dust had accumulated to form a short circuit and as a result a whole panel of the switchboard in the power house was burned out.

The incidents which I have mentioned were practically all due to the dusty and unclean condition of the buildings.

There are some hazards however which are more or less connected with the apparatus used in pulverizing the coal and delivering it to the point of consumption. And while it is true that the reduction of the fire and explosion risks rests largely with those operating the plant in question, yet much can be done through proper inspection by well informed authorities having proper jurisdiction, for instance, such as may come under the regular fire departments, of our cities. And in order to properly understand these hazards and their remedies a working knowledge of the methods and machinery used in pulverized fuel plants is necessary. While it is utterly impossible, in these few minutes, to go into detail, yet perhaps a brief description of some of these methods and machinery may be of some value.

Before coal in a very finely divided state can be used for fuel, it must be crushed, dried, pulverized and then conveyed to the furnace or boiler where it is to be used. Generally speaking there are three distinct classes of pulverized coal equipment in general use and which may be designated as (a) the circulating system, (b) the indirect system and (c) the unit system.

The first two mentioned systems employ practically similar processes, varying perhaps in detail, but differing in the manner in which the pulverized coal is transported to the furnaces.

In the circulating system, after the coal has been pulverized, it is fed in regulated quantities to a fan, by which it is forced in a cloud through pipe lines, ranging from 8 or 10 inches in diameter to 14 to 16 inches. Branch lines loading from the main line to the furnaces carry the coal as may be needed; the surplus coal, which has not been drawn from the main line, returning near the point of beginning where a separator removes the coal dust from the air, and returns it to a storage bin, again to be blown through the line.

In other words it is a continuous circulation of coal dust, and is somewhat analagous to a gas line where the fuel is drawn off as needed. Secondary air lines, independent of the main coal feed line, provide additional air at the burners necessary for proper combustion.

The indirect system transports coal either by compressed air under perhaps fifty or ninety pounds pressure, a screw conveyor, or a combination of air and screw conveyor to bins at the furnaces. From these bins the pulverized coal drops into a small screw conveyor by which it is either fed to an air blast which carries it into the burner, or fed directly to the burner.

The unit system differs from the previously described systems in that the fuel is pulverized at or near the point of use and delivered from the pulverizer in a stream of air directly into the furnace by means of a fan which is a part of the pulverizer.

An important feature of this method of utilizing pulverized coal is contrasted with the circulating and direct systems in the absence of a drier to drive out the moisture.

There are two types of these driers, the direct fired and the indirect fired.

The former type consists practically of a long shell from 3 feet to 5 feet in diameter at one end of which is a furnace and at the other end a stack. The hot gases pass through the center of the shell, coming in contact with the raw coal which is fed into the drier at the stack end.

The indirect fired drier is generally one of two kinds. One kind is the double shell type in which there are two shells, one inside of the other, the raw coal travelling through the inner shell and the hot gases in the opposite direction in the space between the two shells and then returning through the inner shell to the exhaust stack.

The other kind is an inclined single shell, the higher end of which terminates in a brick housing supporting the exhaust stack, the lower end in a steel hood. The furnace for heating the drier is placed between the stack chamber and the hood. The furnace is provided with a large combustion chamber through which the drier shell passes. The hot gases from the furnace fire circulate around the outside of the drier shell passing through the combustion chamber of the furnace.

In the opinion of the writer the drier is directly and indirectly the cause of a large percentage of the fires and explosions which have occurred in coal pulverizing plants, and on the man running the drier, and by that I do not mean the man in general charge, but the man actually shoveling the coal, is placed a great responsibility, exactly in the same way that the man in charge of a battery of boilers has a heavy responsibility. I sometimes think that the average factory or power plant superintendent little realizes the fact. In the case of the man tending the boiler, if he forgets to keep his water in the boiler at the proper level, something pretty costly is liable to happen. If the man tending the drier furnaces happens to improperly perform his duties and allows it to become overheated, the chances are that there will be work for the fire department in that vicinity.

This is very finely illustrated by an explosion and fire which occurred in a large steel plant in Ohio. From evidence obtained at an investigation it is pretty well established that the man tending the furnace of the drier for some reason built up an abnormally large fire so that the coal in the drier ignited, passed into the pulverizer where it came into contact with the fine coal dust with the result that there was an explosion filling the entire building, killing two men and badly burning two others.

Another case in Ohio of a fire, fortunately not injuring any one nor causing serious damage, was due to a slight amount of coal remaining in a compressed air line. Some repairs were to be made in the line and the pressure was supposedly shut off as the pressure gauge registered zero. When the line was broken, a cloud of coal dust was blown directly toward the open door of the furnace drier by a slight air pressure remaining in the line. Immediately there was a cloud of flame which filled the room.

Another plant which the author of this paper visited after and explosion in which two men were fatally and three men painfully burned, had such a hot fire that sparks were flying out in showers at the point where the shell passed through the combustion chamber.

The above illustrations have been given in order to bring before you actual instances of fires and explosions which have been due either directly or indirectly to driers. It would serve no purpose however, unless some lessons might be drawn therefrom by which you could benefit. One thing every Fire Department Chief can do and that is to insist upon absolute cleanliness in a coal pulverizing plant. Dust accumulations must not be allowed and there is one principle that should be remembered. In cleaning up a plant, coal dust should never be swept up with a broom nor should accumulations be dislodged from window ledges, girders, boiler housings or platforms by blowing with compressed air, unless they have been thoroughly wet down or mixed with incombustible dust in the proportion of 7 parts of rock or shale dust to one part coal dust. There are some plants which I have seen that are kept almost spotless by a vacuum system. Another safeguard is to see that the drier is isolated from the rest of the pulverizing plant, if not in a separate building then by a blank masonry wall.

A point which will be of interest to you, is that when you see a building the inside of which is covered with coal dust, you can be sure that if it once starts burning, the fire will spread with far greater rapidity than in a similar building which is clean. In fighting a fire of this nature there is one thing to guard against, and that is a sudden explosion or back fire due to pulverized coal, which may be stored in a bin, being suddenly raised into a cloud, either by a sudden air draft, or perhaps by falling material, and becoming ignited. Every district and battalion chief should familiarize himself with the location of all pulverized coal bins in his district the same as he would the location of permanent oil tanks.

All driers should be equipped with recording pyrometers which shall make a continuous record of the temperature at which the drier is operated. Preferably this chart should be placed in the office of some responsible official, and the thermocouples, or that part of the pyrometer affected by the change in temperature, should be installed at the discharge end of the drier.

One of the greatest sources of fire in a drier room comes from the continued passing of hot gases from the drier furnace through the drier shell when the drier is not in operation. That is when the shell is not revolving and there is not a constant stream of coal passing through the drier. In such a case there is very liable to be a certain amount of coal lying in the drier shell which, by the continued contact with the hot combustion gases, will in time become ignited. Then when the drier is again put in operation this hot coal will either be delivered to the pulverizer or to the dried coal storage bin. If it goes to the pulverizer it is liable to ignite and explode the fine dust therein. If to the dried coal storage bin, there is a possibility of it starting a fire by spontaneous combustion. Or by the continued application of heat from the drier furnace, gas may be generated from the coal in the drier, collect in the shell and explode with disastrous results if brought in contact with an open flame.

While this regulation is largely a matter for the operating official, yet an enactment by the proper authorities requiring all driers to be equipped with bypasses in order to prevent the gases of combustion from entering the shell when it is not in operation will be of great value.

Next to the drier one of the most prolific sources of trouble is the large main which circulates the mixture of air and coal dust around the plant, returning the unused coal to the storage bin. The pulverized coal is driven through this line by air currents induced by a fan and having a pressure of about 8 or 9 ounces per square inch. The fires in this line are often of a smouldering nature which heats the pipe red hot. Should you be called to extinguish such a fire, there is not much that can be done save cutting out the hot section. In any event the blowing fan should be stopped. And the most important precaution of all is that the entire line should be inspected to see that it is entirely free from sparks, glowing particles, or smouldering coal before the fan is again started. Otherwise there may be just enough dust lying in the bottom of the pipe line to make an explosive mixture when raised into a cloud by the starting of the fan which will cause trouble if brought into contact with any glowing particles. So, I would again say that after a fire in a coal circulating line, thoroughly inspect the entire line before starting the fan. An illustration of what will happen if this is not done may be of value. At a manufacturing plant which had a large number of small furnaces drawing fuel from this line, the main fan suddenly broke down and stopped running. The sudden cutting off of pressure evidently permitted a back draft and drew hot particles of coal into the pipe line, where they continued to smoulder until several hours later when the fan was again put in operation. The air current thus started stirred up the dust which had settled to the bottom of the pipe when the fan had stopped; at the same time the smouldering coal was fanned into a flame. The result was an explosion which travelled the entire length of the pipe line, ending up by blowing into pieces the cast iron housing of the fan, killing one man and burning two. From the foregoing illustration it is perhaps needless to say that all pipe lines having to do with the transportation of pulverized coal should be of metal.

At this point it might be well to say that all elevator systems and all screw conveyors should be constructed dust tight. This type of apparatus is probably the worst offender in the matter of throwing off fine dust which will remain in suspension for some time and then settle on any flat surface that it finally reaches. It is a very easy matter to allow the joints to become loose and the cover to jar off.

In the case of elevators it is a safe precaution to have them adequately vented to the outside air. However there is one point to be closely watched in all outside vents connected with pulverized coal and that is that the dust is not discharged in the open air in such a manner that it may be drawn in the doors or windows or settle on the roof of another building.

It is in preventing things of this sort that fire departments are able to cooperate by rigid inspection.

Another source of trouble to users of pulverized coal has been due to fires in storage bins. These bins are of two kinds. Those which have a capacity of fifteen tons or so of dried coal and those which range from one ton to 5 tons each and in which the pulverized coal is kept.

There can be but little doubt that spontaneous combustion plays a large part in the origin of these fires.

I regret to say that there is very little reliable data to be had about spontaneous combustion of coal under the conditions found in pulverized coal plants. Data that relate to amount of air required to circulate in the bin, the temperature to be reached before the coal will begin to rapidly heat, etc. We do know, however, a few things about the spontaneous combustion of coal under other conditions and which may possibly be true under the conditions in question. One is that very fine coal presents a greater area to the air than the same bulk in larger sizes, and therefore, will take up oxygen at a more rapid rate, and that burning is no more or less than a rapid absorption of oxygen. That once coal is heated by other agencies to a temperature of 150 deg. or 175 deg. Fahrenheit, from then on the increase of temperature by conserving its own heat is very rapid and not a great deal of time is necessary to elapse before the temperature of rapid combustion is reached.

The following instances are taken from the records of the "Bureau for Safe Transportation of Explosives and other Dangerous Articles," which is affiliated with the American Railway Association.

Smoke was noticed coming from box car loaded with pulverized coal in bulk. The side doors were opened for ventilation. At first actual fire could not be detected, but the entire load was hot and smoke was rising from the surface of the coal.

Three hours later the fire was seen coming to the surface. Efforts were made to transfer it, but the dust and gas ignited where the men were shoveling, so finally the car was brought to a fire plug and a stream of water was used on the dust from time to time. It was finally necessary to wash the entire load out of the car with a stream of water.

Another case was that of a shipment of pulverized coal in bags. When the doors of the car were opened, smoke came out in great volume. Several bags of the pulverized fuel which had ignited spontaneously were unloaded from the car and the fire extinguished.

One of the large steel companies in the Youngstown district, a subsidiary of the United States Steel Corporation, stated that they had experienced more or less trouble with fire in their pulverized coal bins. There was no way as far as I know, in which burning coal cold be transported to and delivered into the bins. These bins were, however, lined up in close proximity to the heating furnaces and so absorbed a great deal of radiating heat. On the other hand these bins were not of especially large capacity and probably were supposed to be emptied every 24 hours. In studying the situation as to the cause of these fires the following conclusions seemed to be logical:

It is a well known fact that, for some reason, pulverized coal will stick to the sides of the bins and in time become so caked that it is necessary to jar the bins or use bars to loosen the caked coal. In this case the coal fed to the furnace comes entirely from the center.

It is also a well established fact that pulverized coal, or even slack coal, stored in close proximity to a furnace, steam line or stack for exhaust gases heats up much more quickly than otherwise. As the furnaces in question often caked and were very close to the heating furnaces, it is reasonable to assume that the coal clinging to the side was heated by the heat radiating from the furnaces and in time reached a temperature high enough to cause combustion.

It is well, therefore, to have all storage bins and furnace bins containing pulverized coal as far as consistent with operating requirements from furnaces and away from open lights and flames. Locations of such bins should be such that no radiation from furnaces, boilers, steam pipes, flues or other heating appliances can materially raise the temperature of the contents of the bin. Where practicable bins used in connection with pair and sheet furnaces and annealing furnaces shall be placed outside of the main building. Where this is not practicable they should be separated from the bin by a non-combustible partition.

Where a bin has any large amount of burning coal therein, there is one danger that must be guarded against in efforts to extinguish the fire.

If a stream of water is poured on red hot coal there is a likelihood of carbon monoxide gas being generated, and should the bin be in a confined space there is great danger of men being overcome, as carbon monoxide is one of the most poisonous gases ordinarily met with, and a fraction of a percent is deadly when breathed. In the case of a bin of pulverized coal, should a stream of water having any force be placed on the pile, there is the possibility of raising a cloud of dust and having it ignite.

Probably the quickest, safest and most economical way is to get all the coal out of the bin as soon as possible, let it lie in a pile outdoors until the fire is entirely out.

Very often fires occur in driers and the right method of extinguishing it is a matter which requires some little judgment. If the fire has not gotten very hot, it may be put out with water. However, if the fire were to burn and the drier shell get red hot it would hardly do to put water in at that time. While I have no personal knowledge I understand that live steam is a very effective and safe way of putting out a fire in a drier.

In all coal pulverizing plants, electricity plays a large part and it may prove of assistance to you, in your fire prevention work, to know some of the hazards for which to look in a plant using pulverized coal.

In the first place all electric wires and cables should, as far as possible, be carried in conduits. At one plant visited by the author of this paper the bin for pulverized coal also acted as a support to wires carrying several hundred volts of electricity.

All switches should, if possible, be placed on the outside of any building in which coal dust is liable to accumulate; if this is not possible, they should be of the oil immersed type. The necessity for this is shown in the incident mentioned in the first part of this paper in which a switch was short circuited by dust and burned out a switchboard panel.

Motors which are liable to spark are a potential source of danger. Perhaps the best illustration of the danger of coal dust is the explosion which occurred at the New Brancepeth Colliery in England. The pulverizer was operated by a 25 hp 500 volt dc motor. The motor was enclosed but not explosion proof and stood on a platform about six feet from the floor. A short circuit of one of the armature coils caused much sparking, thereby igniting the coal dust inside the motor casing, causing an explosion of sufficient force to blow off the sheet iron cover over the commutator end of the motor.

The flame thus produced was sufficient to explode the fine dust held in suspension within the building, the resulting flames extending six feet outside the open door and for a height of 15 feet.

The United States Bureau of Mines and prominent English authorities have made extensive tests in order to determine whether or not a cloud of coal dust can be ignited by an electric arc or spark. For instance with a direct current of 100 volts and 100 amperes in 62 trials ignition was obtained in 20 cases when the arc was formed. With a direct current of 240 volts and 27 amperes in 23 trials ignition was obtained in 19 cases. A motor of five horsepower on a 220 volt circuit ignited a dust cloud once out of every ten trials, while a ten horsepower motor on the same voltage ignited a dust cloud almost every time. Therefore motors of the non-sparking type, preferably squirrel cage motors, are the nearest explosion proof motors now available. All machinery should be thoroughly grounded to prevent sparks due to static electricity.

Whenever inspections are made of fire hazards around any kind of plant where there is a prevalence of dust, whether it be pulverized coal or fine grain dust, aluminum dust, or, in fact any kind of dust, very great attention should be given to the electrical equipment and especially sparking, motors, exposed switches and electric wiring.

When portable electric lamps are used to illuminate any place in which there is liability of a pulverized coal dust cloud forming, the bulb should be protected with a wire guard. There is, however, a danger in using these portable lights around dusty bins because of possible defective connections and short circuits. Ordinary hand flash lights are handier and safer.

In closing, I would impress upon your minds one thing, that a cloud of coal dust and air mixed in the proper portions are as dangerous as a cloud of unconfined mixture of natural gas and air; that a structure covered with coal dust, even though the dust has been partially consumed, will be a hard proposition to fight, once it catches fire, because if this dust once gets in suspension in the vicinity of flames, the probability of an explosion is very great, and an explosion which would have no mercy on any of your men who might be fighting the fire in the vicinity. Every district and battalion chief should acquaint himself with those plants using pulverized coal in his vicinity, and familiarize himself with the plant lay-out and at the same time rigidly inspect it, keeping in mind the old saying "Cleanliness is next to Godliness," and that it is far easier to prevent a fire in a coal pulverizing plant, than it is to put it out, once it is started.

POWER AND MECHANICAL EXPOSITION

Announcement has been made of the National Exposition of Power and Mechanical Engineering to be held at the Grand Central Palace, New York, from December 7 to 13, inclusive (except Sunday intervening) by the managers of the Exposition.

The Exposition was decided upon by a group of engineers and manufacturers who had felt the need for such a means of having men get together, exchange ideas, see the latest development in equipment and lay problems before the manufacturer.

The business opportunity where a manufacturer may meet a large assemblage of power plant and mechanical engineers and capitalists interested in power, is significant to firms keen for such business. A number of progressive manufacturers have already engaged space for their exhibits.

The Exposition will immediately follow the annual meeting of the American Society of Mechanical Engineers and it is expected that the exhibits will supplement the programs and discussions at the professional meetings of the Society. The Professional Divisions of the Society will hold sessions relating to Fuels, Stokers, Steam Power Plants, Railroads, Steam Utilization in the Paper Industry, Textile and Gas Power, and it is expected that the exhibits at the Exposition will throw interesting light on the papers presented at these sessions of the A.S.M.E. meeting.

That the Exposition will be comprehensive may be inferred from the plans which are to include exhibits of every type of machine, apparatus, equipment, instrument device, and the various materials and supplies necessary in the operation of the complete power plant. The Committee decided that its keynote should be "an Exposition of apparatus employed in the generation, distribution and utilization of power."

LETTERS TO THE EDITOR

Dominion Iron & Steel Company, Ltd.
Head Office and Works, Sydney, Nova Scotia
Canada

OFFICE OF ECONOMY ENGINEER

June 16, 1922.

Editor Blast Furnace and Steel Plant,
Pittsburgh, Pa.

Dear Sir—I have read with much interest the article by Mr. F. G. Cutler on the "Reduction of Fuel Wastes in the Steel Industry," published in your issue of May.

It is a subject that in all industries is deserving of far more study than it has had in the past.

A statement is made, however, which would seem to call for some comment or correction. In referring to by-product gas the writer says, "As gas holders of sufficient capacity to absorb the fluctuations have not been found advisable, it becomes necessary to schedule the use of gas by consuming departments in order partially to equalize the consumption." That is just what has to be done where there is no holder, but if such conditions obtain in any plant where there is a holder it must be that the holder is wrongly placed or far too small. Otherwise, except for great variations, such as a radical change in production schedule at the ovens or the shutting down for a long time of one of the main consuming departments, a remarkably uniform pressure can be held.

Assume a plant producing 12,000,000 cu. ft. of surplus gas per day. A million foot holder would provide for all ordinary disturbances and its cost is almost negligible compared with the economies which can be demonstrated.

While I cannot claim that the mantle of any prophet has fallen on me yet I will venture the assertion that the time is not far distant when gas holders will be used to control the pressure of blast furnace gas, or for combined blast furnace and coke oven gas.

We cannot expect to get continuous high efficiency out of boilers or stoves fired with gas unless the pressure of the gas is reasonably uniform. Nor can high boiler rating be continuously obtained under the same conditions except at the expense of serious heat loss at times of high pressure.

By regulation of the gas pressure and supplying the air by means of a constant speed fan there is no reason why much higher efficiencies cannot be obtained and the necessary expenditure will be small compared with the saving made in the fuel balance for the entire steel plant.

Coke oven gas or tar, or a combination of the two, or a combination of coke oven gas and blast furnace gas, actually show a much lower Btu. consumption in open hearth furnaces than producer gas, because with the latter a very considerable producer loss has to be accounted for, and coke oven gas or tar, or producer gas, with air supply regulated by a fan, shows from 30 to 50 per cent lower Btu. consumption than for the same fuels with natural draft.

Except in rare cases it is hard to justify the use of waste heat boilers—particularly in new installations. The installation of proper apparatus and situ to better advantage and at a lower cost than to carry it elsewhere with the consequent loss and added installation necessary to recover it in the form of steam.

Yours very truly,
F. E. Lucas,
Economy Engineer.

MEETING OF ELECTRIC STEEL FOUNDERS' RESEARCH GROUP

Officers and operating officials of each plant holding membership in the Electric Steel Founders' Research Group held one of their regular meetings, for several days, immediately following the convention of the American Foundrymen's Association at Rochester, N. Y. The group meeting was held at East Aurora, N. Y., because of its accessibility to Rochester, where the group members had participated in the foundrymen's annual meeting. C. R. Messinger of Milwaukee, who is very active in this research group and is prominently connected with several foundry concerns including the Sivyer Steel Casting Company, was selected at Rochester as the next president of the American Foundrymen's Association.

Recently in the technical press there appeared an extensive description of the co-operative technical plan followed by this research group, which is made up of representatives of the Electric Steel Company, Chicago; the Fort Pitt Steel Casting Company, McKeesport, Pa.; the Lebanon Steel Foundry, Lebanon, Pa.; the Michigan Steel Casting Company, Detroit, and the Sivyer Steel Casting Company, Milwaukee. At the convention of the American Foundrymen's Association the results of comprehensive investigations in testing molding sand were presented by R. J. Doty of the Sivyer Company, who had been delegated by the group to carry on such a research for its own account. The group made some of its information on the subject available to the industry at large. The result of this, as announced at the foundrymen's convention, has aroused great interest, particularly as it was stated there that certain testing methods developed by the research group have been approved by the sub-committee on tests of the Joint Committee on Molding Sand Research organized by the American Foundrymen's Association and the National Research Council, and participated in officially by the American Society for Testing Materials and numerous technical departments and bureaus of the U. S. Government.

It is stated that at East Aurora further steps for the group molding sand investigation were planned, and interesting reports were presented by the members on annealing, electric furnace practice, the elimination of slag in castings, and other matters that now engage the attention of the group members.

STEEL COMPANIES CONSOLIDATE

Plans will probably be consummated at the meeting, July 7th, of the directors of the Penn Seaboard Steel Corporation, Philadelphia and The Carpenter Steel Company, Reading, Pa., whereby the two companies will consolidate their business.

NEWS OF THE PLANTS

The Donner Steel Company, Inc., Buffalo, N. Y., has disposed of a bond issue of $5,000,000, a portion of the proceeds to be used for general expansion, additions to working capital, general financing, etc. The company's plant now comprises over 65 acres of land, improved with two blast furnaces, ten open-hearth furnaces, blooming mill, plate mill, billet mill, three merchant mills and other miscellaneous works buildings. Production is devoted to pig iron, blooms, billets, slabs, small shapes, sheared plates, etc. William H. Donner is president.

The Colonial Steel Company, Keystone Building, Pittsburgh, Pa., has plans nearing completion for the construction of a new one-story plant building, on property recently acquired at 2121 St. Clair Avenue, Cleveland, Ohio, to be used as a general heat-treating works. The estimated cost has not been announced.

The Empire Tube & Steel Company, College Point, L. I., will commence the immediate construction of a new plant at Hudson, N. Y., for the manufacture of pipe tubing and kindred steel products. A site has been acquired in the Industrial District. It will be one-story, 100 x 300 feet, and is estimated to cost in excess of $75,000. The building contract has been let to the L. A. Scott Construction Company, Grand Central Terminal, New York, N. Y. C. J. Thompson, general manager, is in charge.

The Newton Steel Company, Youngstown, Ohio, has arranged for a bond issue of $750,000, the majority of the proceeds to be used for proposed plant additions for increased capacity. Work will be placed under way at an early date for six new sheet mills, and contract for the structural steel frame for the buildings has been awarded to the McClintic-Marshall Company, Pittsburgh, Pa. It is proposed to inaugurate work at once and have the extension ready for service at the earliest possible date. The present works comprise a total of 10 mills. The company also has plans under way for the construction of a new warehouse.

The Penn Seaboard Steel Corporation, Franklin Bank Building, Philadelphia, Pa., is perfecting plans for the purchase of the plant and business of the Carpenter Steel Company, Reading, Pa., for a consideration said to be about $8,000,000. The Carpenter works has a present capacity of about 36,000 tons a year, and it is said that the new owner will increase this output in the future.

The Cleveland Structural Steel Company, 6600 Park Avenue, Cleveland, Ohio, has had plans prepared for the construction of a new plant on East Sixty-fifth Street, for a general steel fabricating works. It will be one-story, 60 x 200 feet, and is estimated to cost about $50,000.

The Gulf States Steel Company, Birmingham, Ala., is planning for extensions and improvements in its plant at Gadsden, Ala., to cost about $125,000, including machinery and operating equipment. Work will be placed under way at an early date. C. A. Moffett is president.

Following a merger of the Atlas Crucible Steel Company, Dunkirk, N. Y., and the Electric Alloys Steel Company, Youngstown, Ohio, plans are being arranged for the construction of an addition to the Dunkirk works, to comprise a number of buildings, all to be devoted to alloy steel production. The consolidated company also proposes to build an addition to the present plant of the Electric Alloy division, at Charleroi, Pa., as well as the construction of a new plant at Niles, Ohio. Louis J. Campbell will be chairman of the Board of Directors of the new company, and Arthur H. Hunter, president.

The Sharpsville Furnace Company, Sharpsville, Pa., has perfected plans for extensions and improvements to completely modernize its works. The present blast furnace will be rebuilt and enlarged, providing considerable increase in capacity. A new skip-hoist will be installed; new ore bins constructed, and other work of miscellaneous character carried out. It is said that the expansion program will involve close to $150,000. The company is operated by the Allen S. Davison Company, Pittsburgh, Pa.

The Steel & Tube Company of America, Chicago, Ill., has disposed of a bond issue of $6,000,000, the proceeds to be used for extensions in its plant at Indiana Harbor, Ind. The work will include two new mills, bringing the capacity of the plant up to about 100,000 tons per annum. Miscellaneous auxiliary buildings will also be constructed. A. A. Schleishinger has been elected chairman of the Board of Directors.

Gehret Brothers, Bridgeport, Pa., operating a structural steel fabricating plant, have plans in preparation for the construction of a new one-story shop, to be used for general operations. It will be 125 x 140 feet, and is estimated to cost about $42,000, including equipment. Charles Gehret is head.

The Dominion Alloy Steel Company, recently formed with a capital of $15,000,000, will break ground at once for its proposed new plant on property in the vicinity of Sarnia, Ont., on the St. Clair river front. The site comprises a total of 1,200 acres of land, including about 370 acres secured a number of months ago by C. Harold Wills, Marysville, Mich., head of the Wills-Sainte Claire Automobile Company, with plans to use the property for a Canadian branch factory. The plant will be devoted to the manufacture of high carbon steel and steel alloys, and is estimated to cost close to $5,000,000, including machinery. William B. Boyd, Toronto, Ont., is president of the company; George A. Simpson, Hamilton, Ont., is vice president in charge.

The Tichener Iron Works, 7 Frederick Street, Binghamton, N. Y., is considering plans for the construction of an addition to its plant for increased capacity. It is estimated to cost about $50,000, including equipment. Work will be inaugurated at an early date. L. E. Barnes is secretary.

The Cranberry Furnace Company, Cranberry, N. C., with branch plant at Johnson City, Tenn., has preliminary plans under way for improvements in its blast furnace, to include relining and other work. Hammond Prosser is secretary.

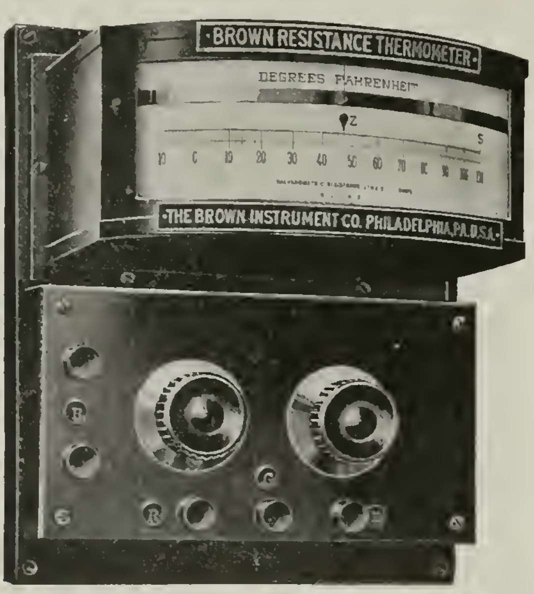
The plant and property of the Connecticut Electric Steel Company, Hartford, Conn., have been acquired by M. W. Taggart & Company, New York.

WITH THE EQUIPMENT MANUFACTURERS

A DIRECT READING RESISTANCE THERMOMETER

Resistance thermometers have certain notable advantages as compared with other temperature measuring devices which make them particularly valuable for many industrial processes. One particular advantage is in the ability to produce a high temperature instrument in which the whole temperature scale may cover a range of 25 deg. F. only. This is very difficult to obtain with a direct reading instrument operating on any other principle.

There are many applications where throughout a process the temperature must be known with extreme accuracy and where the temperature is maintained constantly within close limits. For example, it may be desirable to maintain a temperature of 820 deg. F. and the temperature will never drop below 750 deg. F. or rise above 900 deg. F. A thermo-electric pyrometer would usually be supplied to meet such a requirement with a total range of 0 to 1,000 deg. F. If the scale can have a maximum of 100 or 150 divisions, each graduation on the scale would be equivalent to 10 deg. F.


BROWN RESISTANCE THERMOMETER
DEGREES FAHRENHEIT
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THE BROWN INSTRUMENT CO. PHILADELPHIA, PA. U.S.A.

Fig. 1—Brown Direct Reading Resistance Thermometer.

If, however, a direct reading resistance thermometer is used, the scale can be graduated from 750 deg. to 900 deg. F., and each division is then equivalent to 1 deg., affording much greater accuracy in the readings.

The fundamental principle of the resistance thermometer is the well-known physical property of metals, except special resistance alloys, of change in resistance with change in temperature. This change in resistance can be accurately measured and a scale calibrated in temperature degrees.

The bulb or coil of wire which changes in resistance is usually of nickel for temperatures to 300 deg. F. (150 deg. C.) and of platinum for higher temperatures to 1800 deg. F. (1000 deg. C.). The dimensions of the bulb can be very small to secure sensitivity. A nickel wire bulb can be supplied with active part 1 in. long and 3/16 in. diameter. This can be supplied in a protecting tube for moderate temperatures with an outside diameter of only ¼ in.

Three wires lead from the bulb to the instrument. This three wire system eliminates any effect on the indications of the instrument due to changes in temperature along the wiring connecting the bulb to the instrument. The length of wiring is immaterial in the Brown three wire system and bulbs can be placed up to 1000 ft. distant from the instrument using No. 14 gauge copper wire or up to 2500 ft. distant (half a mile) with No. 10 gauge copper wire.

A recent development has been the perfection of a direct reading resistance thermometer. For years resistance thermometers have been built on what is known as the zero or null basis. In this type of instrument a galvanometer pointer must be brought to zero and a reading is then taken on a scale mounted in front of a rheostat. While quite accurate this method has the disadvantage of not being direct reading and the operator must obtain a balance by adjusting the slide arm of the rheostat so that the galvanometer indicates zero before the temperature reading is secured.

The Brown direct reading resistance thermometer has a scale graduated directly in temperature degrees as illustrated. To check the instrument for zero reading, the left hand knob is turned to Z, and then to S to check the instrument with a standard resistance at the top graduation on the scale, and in the third position the instrument is operated directly off the temperature bulb. The rheostat is the right hand knob on the instrument for adjusting the voltage. This check of the instrument while recommended daily, need only be made every few days even where dry cells are used to operate the instrument, since the current required is infinitesimal, and dry cells last four months without replacement. Where storage batteries are used, a less frequent check is satisfactory.

Through means of a switch, the instrument can be connected to any number of resistance thermometer bulbs installed in different locations. Where used in dry kilns the instrument can be used to measure both temperature and humidity, one bulb being subject only to the air temperature, the second bulb being covered by a wick leading into a tank of water. This type of bulb, for measuring humidity, affords a means of instantly reading the difference in temperature of both the wet and dry bulbs and from suitable tables the per cent of humidity is available. This construction enables the measurement of both temperature and humidity at great distances.

Applications where the Brown direct reading resistance thermometer can be used to advantage are in power plants for many temperature measurements, for the temperature of coal piles to prevent spontaneous combustion, oil cracking stills where extremely accurate measurements of temperature are required, chemical processes, refrigerating rooms, public buildings and schools, for the approach of frazile or anchor ice temperatures in hydro-electric power plants and numerous other applications.

This new direct reading resistance thermometer is the product of the Brown Instrument Company, Philadelphia, Pa.

The Allegheny Steel Company, Brackenridge, Pa., has perfected plans for immediate work on a number of improvements and extensions in its local plant. The present plate mill will be converted into a jobbing mill, and the blooming mill will also be subjected to a number of changes, to provide for the handling of larger ingots and the production of sheet bars, slabs and billets of varying sizes. The remodeled plate mill will be used for the rolling of annealed sheets of widths up to 72-inch.

The Open Hearth

E. J. Lowry, recently became identified with Hickman, Williams & Co., pig iron brokers, as a service engineer. Mr. Lowry was formerly connected with the Oliver Chilled Plow Works, South Bend, Ind., in the capacity of metallurgist.

√ √

James Walsh, superintendent rolling mills, Illinois Steel Company, South Chicago, Illinois, has resigned to become assistant general superintendent Inland Steel Company, at Indiana Harbor, Indiana.

√ √

E. G. MacKay has retired as superintendent of the steel plant of the Nova Scotia Steel & Coal Company, Sydney Mines, N. S., and will leave shortly for Pittsburgh where he is expected to take an important position.

√ √

William B. Gillies was recently appointed general superintendent of the Mark plant, the Steel & Tube Company of America, at Indiana Harbor, Ind., to succeed A. H. Beale, recently elected vice president in charge of operations.

√ √

John Sincock, general superintendent of W. J. Rainey, Inc., retains his own title and assumes the additional duties at Connellsville, Pa., of L. L. Willard, vice president, who resigned on account of ill health.

√ √

W. B. Pierce, who for 12 years was superintendent of the Buffalo Bolt Company, North Tonawanda, N. Y., and for the past two years connected with the Pierce-Brown Company, that city, has been made works manager of the Graham Bolt & Nut Company, Pittsburgh. Mr. Pierce took up his new duties June 1st.

√ √

T. H. Edwards recently resigned his position as superintendent of steel works department, which position he has held for many years, Benwood, W. Va., Plant of the Wheeling Steel Corporation, and has retired from active connection with the industry. He has been in the steel business for fifty years. Mr. Edwards will join his family now in Denver, Colorado. His successor has not as yet been named.

√ √

Morman R. Seidle recently resigned as assistant general manager of the James G. Heggie Company, Joilet, Illinois, to become works manager of the General Boilers Company, Waukegan, Illinois. The General Boilers Company manufactures steel-welded boilers (Pacific type) for all general heating purposes.

√ √

John Dunlop for many years assistant manager of the Wellsville, Ohio, Plant of the American Sheet & Tin Plate Company, has resigned because of ill health. William W. Knox will be his successor. Mr. Dunlop was in the employ of the mill for more than 26 years.

√ √

H. V. Smallwood, purchasing agent at the Portsmouth, Ohio, works of the Wheeling Steel Corporation since 1918, has been transferred to Wheeling and promoted to the position of general purchasing agent, having charge of purchases of raw materials for the entire company. Mr. Smallwood, before going to the Portsmouth, Ohio, works was with the Youngstown Sheet & Tube Company, Youngstown, Ohio, and prior to that with the La Belle Iron Works, Steubenville, Ohio.

√ √

B. L. Morgan was recently appointed superintendent of the Erie Specialty Company, Erie, Pa.

√ √

Fred B. Quigley has been appointed superintendent of open hearth furnaces and the Bessemer department of the Carnegie Steel Company, Youngstown, Ohio, succeeding William C. Bulmer, resigned. On June 1st Mr. Bulmer assumed charge of the sales and installation of water-cooling appliances for openhearth furnaces of the Blaw-Knox Company, Pittsburgh. Mr. Quigley was assistant superintendent of blast furnaces since 1912 and has been connected with the Youngstown district for 14 years, following his graduation from Case School of Applied Science. From 1912 until two years ago he was assistant blast furnace superintendent at the Ohio works, in immediate charge of the company's furnace at Niles, Ohio. Upon banking of the Niles furnace, Mr. Quilgey was transferred to the Ohio works.

√ √

Thomas E. Raymond, for three years superintendent of the Clinton, Mass., works of the Wickwire Spencer Steel Corp., Worcester, Mass. and Buffalo, has resigned because of ill health. He is succeeded by George M. Johnston, who has been connected with the same works for 13 years, starting as an office boy at 14.

The Open Hearth

Albert Maheu, Worcester, Mass., until recently superintendent of the General Spring & Wire Company, Detroit, has taken a position with the Wetherell Bros. Co., Boston, Mass., steel merchants, which company he will represent in New England territory.

* * *

Andrew Glass has resigned as vice president in charge of operations, Wheeling Steel Corporation, effective July 1st and will be succeeded by William J. Stoop, who has been assistant to Mr. Glass. The latter, who is a nephew of Alex Glass, chairman Wheeling Steel Corporation, has been identified with the companies now comprising the Wheeling Steel Corporation since early manhood. He was general manager of the Portsmouth Ohio, works, Whitaker-Glessner Company, when the Wheeling Steel Corporation was formed in 1920 and was made president of the Whitaker-Glessner Co. and vice president of the Wheeling Steel Corporation. Mr. Glass will be associated with W. M. MacCleary in a brokerage business in iron, steel and allied products.

* * *

W. Woodward Williams has been appointed vice president of Titan Iron and Steel Company, mechanically puddled wrought iron, Newark, N. J. Mr. Williams graduated from Harvard in 1905. After six years in the mills of the Carnegie Steel Company at Pittsburgh, Duquesne and Youngstown, he entered the sales department of the Bowne-Fuller Company, Cleveland, and was later appointed manager of its Pittsburgh office. In January, 1914, he became general manager of sales of the A. M. Byers Company, Pittsburgh, and subsequently was made its general manager. In August, 1919, he became general manager of the Reading Iron Company, and afterward was elected vice president, in charge of sales and operations. In September, 1920, he became associated with the Pittsburgh Gage & Supply Company, the largest jobber of wrought iron pipe in the United States, resigning the vice presidency on May 31, 1922, and entering immediately upon his present office of vice president of the Titan Iron & Steel Co., Inc.

* * *

James J. Zimmerman, until recently assistant superintendent of the Mechanical Department of the Reading Iron Company in Reading, Pa., has joined the engineering force of the Elliott Co. of Pittsburgh and Jeannette, Pa., manufacturers of pumps, condensers and steam equipment.

* * *

A. J. Maskrey, general superintendent of the Carnahan Sheet & Tin Plate Co., Canton, Ohio, for 11 years, has been made general manager of the Falcon Tin Plate Company, which recently took over the Carnahan company. Charles A. Streb, paymaster and secretary of the Carnahan company, has been appointed general superintendent of the Falcon company.

* * *

M. W. Froney, assistant chief engineer on the Gogebic range for Pickands, Mather & Company, Cleveland, has been made superintendent of the Carey mine.

* * *

Albert L. Andrews, one of the founders of the Andrews Steel Company, and the Newport Rolling Mill Company, Newport, Ky., died suddenly at his home in that city, June 19th. Mr. Andrews was horn in Cincinnati in 1842 and retired from active business life four years ago at the age of 76. He is survived by three sons, Albert K., Joseph Gaff and Frank N., all actively associated with the management of the Newport Company.

* * *

A. B. Neumann, who as chief engineer for the United States Steel Corporation designed and built the Gary plant, and who for the past three years has been chief consulting engineer for the Steel and Tube Company of America, has opened offices as consulting engineer in the Peoples Gas building, 122 S. Michigan avenue, Chicago.

Later he designed and built the East Works of the American Rolling Mills Company. In 1916 he made the layout for the original plant of the Mark Manufacturing Company at Indiana Harbor, Ind., which was constructed in 1917 and 1918.

During the greater part of 1917 and 1918, Mr. Neumann designed and constructed the Pittsburgh Steel Products Company's plant at Allenport, Pa. While he was chief consulting engineer for the Steel and Tube Company of America he laid out and built this concern's two vessel Bessemer plant at Indiana Harbor. Recently he has been engaged in making appraisals of steel, power and manufacturing plants.

Some Pointers on By-Product Coke Oven Operations

AMERICAN COKE OVEN PRACTICE

Dr. G. Lishman and Mr. A. H. Middleton have given their impressions of American coke oven practice, before the Northern Section of the Coke Oven Managers' Association. Mr. Middleton, in the course of his remarks, pointed out that in America, nearly all ovens were made with silica bricks, and that the ovens, in general, were much larger than the British type, being from 10 to 12 ft. high, the coking chambers being about 38 ft., but that the width was only from 15 to 18½ in.

Carbonizing temperatures ranged from 1,250 deg. to 1,350 deg. C. So-called "black ends" were no objection, as blast-furnace men liked to see a little flame when pushing an oven, as they declared it showed hydrocarbons to be present.

American coke, from wall to cleavage point, was more like the medium zone in British coke. One concern in the U.S., over a month's working, used only 15 cwt. of coke per ton of pig iron.

Dr. Lishman said that American coke was very small, that for blast furnaces, resembling good breeze. Wet coal could not be employed, as the silica brick would crumble or fall to pieces after about two years. The present cost of American plant was about $50,000 per oven, but they were elaborately fitted with all sorts of recorders and meters.

Labor control might be called a more or less benevolent despotism, and there was no cokemen's Union. A ram man, in America, would push and level 80 to 100 ovens per shift, as against the fixed shift of 13 ovens in Durham.

An interesting discussion followed, touching mainly upon by-product yields, which were declared to be quite as high as our own, in spite of the high temperature used, and which might be expected to break them up. Questions were asked and answered, relative to central quenching, the appearance of coke, the use of dry coal, and silica linings.

THE MANUFACTURE OF COKE

In a paper upon the manufacture of coke for industrial purposes, read by Mr. A. D. Young, before the Lancashire branch of the Institution of British Foundrymen, the necessity was pointed out for a hard, non-friable coke, with a well-developed cell structure. It should have a large carbon content, with low proportions of ash, sulphur, phosphorus and water.

Reference is made to the poor quality slacks, from which practically the whole of the coke now produced, is derived, and the process of washing is described. Details are given of the two processes followed in the production of coke for fuel purposes, either by carbonization in bulk in ovens, or by carbonization at gasworks in horizontal retorts.

The early types of coke ovens are expounded upon, of which the beehive oven, which answers so well for certain types of coal, retains its place even down to the present moment.

IGNITION TEMPERATURE OF COAL

In an interesting paper, Ray W. Arms, in the Illinois University Bulletin summarizes his conclusions in the following words:

(a) The "Ignition Temperature" of coal means nothing unless it is applied to some definite point in the process of heating the coal, which can easily be determined and duplicated.

(b) The temperature at which the coal glows seems to be the most logical point to choose as the ignition temperature. It is easily observed, can be duplicated with a fair degree of accuracy, and marks the beginning of visible combustion.

(c) The glow point is probably affected by the oxygen contents of the coal, and perhaps by other agencies made active by weathering.

(d) The glow point is not affected by ash, moisture, size of particles, slight variation from the normal air supply, nor by the rate of heating.

(e) There is at present no indication that the glow point bears any direct relation to the liability to fire whilst in storage. Perhaps if a series of tests were made on the glow points of freshly mined coal, new information would be brought to light, which would lead to the discovery of some more definite relation between the glow point and the firing qualities of the coal.

TEST PROPOSALS FOR COKE FOR BLAST FURNACE AND FOUNDRY PURPOSES

Dr. Koppers in the April 13, 1922 issue of Stahl und Eisen has the following to say regarding test proposals.

With proper coke as shown by American blast furnace practice, one ton of pig can be produced with 527 kilos of carbon, gasified by air in front of the tuyeres, and with less highly heated blast than is used in Europe. With our usual higher carbon consumption, the blast-furnace generally suffers from too high a temperature in the shaft.

The writer condemns a number of the usual methods of dealing with this evil, and recommends his own practice, viz., drawing off some of the gases between the bosh and the shaft. He contends that coke, exceeding a temperature varying between 600 deg. and 800 deg., according to the variety of coal, becomes more difficult to burn. Using such coke, therefore, as the shaft temperature reads, the former becomes more and more overheated, and hard to burn.

Analysis shows that the carbon in coke is compounded with certain quantities of oxygen and hydrogen. Tests showed that the specific gravity of a certain coke, upon heating from 700 deg. to 950 deg., actually rose by almost 20 per cent. For blast furnace purposes, coal should be so treated that the specific temperature of the coke does not exceed 650 deg. to 800 deg., according to the quality of coal. The coke should not contain more than 8 to 10 per cent ash, and less than 1 per cent sulphur and 3 per cent water. It should not break into small pieces, and at 700 deg. to 750 deg., a lively evolution of gas should take place.

Foundry coke, on the contrary, should be hard to burn, and made from coal, with the lowest possible amount of volatile matter.

The author favors the inclined hoist above all other means of charging the blast-furnace, and remarks that the latest types of furnace are absolutely dwarfed by huge, subsidiary, but costly iron erections. Skip loaders were tried, he says, in several American works, but abandoned in favor of the inclined lift, which gives more equable charging. He cites the Illinois Steel Co., where one man per shift looks after the charging of a blast furnace, producing 700 tons per 24 hours.

TRADE NOTES

Orton & Steinbrenner Company—manufacturers of locomotive cranes, grab buckets and coal curshers, have moved their offices from the 11th to the 19th floor of the Transportation bldg., 608 So. Dearborn st.

Iron Products Corporation, New York and its subsidiaries The Central Foundry Company, Central Iron and Coal Company, Central Radiator Company, Molby Boiler Company, announce the opening of a district sales office in the Jefferson County Bank building at Birmingham, Alabama.

Combustion Engineering Corporation announce that Mr. A. D. Halporn, who has been associated with their Philadelphia Sales Staff for some time, has now become a member of their New York Sales Force.

J. G. Barry, sales manager of the General Electric Company since 1917 and manager of its railway department for many years and A. H. Jackson of the Law Department, were recently elected vice presidents of the company at a meeting of the board of directors.

Witherbee, Sherman & Company have appointed Freyn, Brassert & Company consulting engineers for the construction of a new blast furnace at Port Henry, New York.

Mr. John F. Schurch has been elected a vice president of Manning, Maxwell & Moore, Inc., and on June 1st will take charge of their western sales, with headquarters at the Company's Chicago Office, 27-29 North Jefferson st., Chicago.

Announcement is made of the incorporation of the Raymond Brothers Engineering Company, Chicago, for the manufacture of equipment for "Rayco" Pulverized Coal Systems for the utilization of pulverized coal as fuel in metallurgical operations, cement plants, and under boilers in power plants, and for the designing and installation of such systems. The new company takes over the business of the American Industrial Engineering Company of Chicago, which has made a number of such installations, and Mr. L. H. Bergman, who has been Secretary and Chief Engineer of the American Industrial Engineering Company, will remain as General Manager of the new company.

The Sanford Riley Stoker Co. has merged its interests with the Underfeed Stoker Company of America and its affiliated companies, the A. W. Cash Co., valve manufacturers, Decateur, Ill., the Craig Damper Regulator Co., Detroit, Mich., and the Underfeed Stoker Co. Ltd of Canada. The products of the combined companies, which include the Jones, Riley and Murphy stokers, makes one of the most complete lines of mechanical stokers ever brought together. Manufacturing will be concentrated at Detroit, Michigan and Worcester, Mass.

The Pennsylvania Pump and Compressor Company of Easton, Pa., has recently opened a district office at 105 West Monroe street, Chicago, Ill., with H. M. Montgomery in charge.

Tate-Jones & Company, Inc., Furnace Engineers, Pittsburgh, Penna., report the following contracts closed by them within the last two weeks.

Six (6) furnaces for the Wheeling Steel Corp.

Six (6) furnaces for the Newton Steel Company, Newton Falls, O.

One (1) furnace for Superior Sheet Steel Company, Canton, O.

Equipment for a new power station in the City of Maracay, Venezyela, South America, has been ordered from the Westinghouse Electric & Manufacturing Company by General Juan Vicente Gomez, President of the Venezuelan Republic. The equipment ordered by the Venezuelan President consists of one 500 kv-a water wheel generator; step-up transformers of sufficient size to accommodate two generators; 24 kilometers of transmission line with steel poles and step-down transformers for a sub-station.

The Ever-Tyte Piston Ring Division of the Walter A. Zelnicker Supply Co., St. Louis, Mo., has appointed J. H. Perkoski as their Pittsburgh district representative. Mr. Perkoski has been associated with the Sturtevant Mill Co. for many years as Western Sales Manager and special representative. Mr. Perkoski has appointed Mr. Fred C. Laughran, formerly connected with the Jones and Laughlin Steel Company and Mr. Bernard Perkoski as his representatives to introduce The Ever-Tyte Piston Ring in the steel plants of this district. Several installations in the National Tube Co. and the Jones and Laughlin Steel Co. mills have proven the merit of Ever-Tyte Rings.

TRADE PUBLICATIONS

A line of velocity stage turbines especially designed for high pressure and high temperature steam is described in a 28-page catalogue issued by the De Laval Steam Turbine Co., of Trenton, N. J. The cast steel steam chest is located in the casing cover in order to avoid the conduction of heat to the bearings. In addition to the speed governor and governor valve, there is an independent valve controlled by an automatic overspeed trip. The turbines are built in sizes up to 1,200 hp, and are designed to be directly coupled to high speed centrifugal pumps and blowers, small ac and dc generators, and by means of double helical speed reducing gears, to large pumps and blowers, medium size generators, belt pulleys, rope sheaves and slow and moderate speed machinery.

"Regulating Boiler Feed Water" is the title of a booklet which has just been published by the Northern Equipment Company, Erie, Pa. The subject has been treated in an entirely new way, the object being to cover the subject of boiler feed water regulation completely and yet very briefly. To accomplish this purpose, free use has been made of a graphical method of presentation: charts showing the effect of feed water regulation on water input, steam output, feed water temperature, etc., also other charts, photographs, etc. There are only twenty pages and the booklet can be read in less than fifteen minutes.

The Conveyors Corporation of America, 326 W. Madison street, Chicago, have issued an illustrated booklet entitled "Cut Ash Handling Costs" which should prove to be of value to the power plant executive interested in reducing the boiler room overhead.

The Electric Furnace Construction Company of Philadelphia have recently published two interesting catalogues, one on Electric Furnaces for Melting, Refining and Superheating of Iron and Steel, the other describes the "Electro" Steam Boiler developed by F. T. Kaelin, Chief Engineer of the Shawinigan Water and Power Company.

Whiting Corporation have just issued a new railway equipment catalogue No. 160, which supersedes No. 145. This catalogue contains a description of the company's locomotive hoists, coach hoists, cranes, turntable tractors and miscellaneous other equipment.

The Conveyors Corporation of America, 326 West Madison street, Chicago, Ill., have just issued a new booklet describing their American Cast Iron Storage Tank, which is designed for holding loose, bulky, dry materials for storage or transfer. The tank is sectional and may be secured in a number of sizes. Copies of the booklet may be secured by addressing the Conveyors Corporation at 326 W. Madison street, Chicago, or on application to their district representatives.

"The Surface Combustion Co., Industrial Furnace Engineers and Manufacturers, of 366 Gerard ave., Bronx, New York City, are issuing a series of bulletins pertaining to industrial furnaces.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., AUGUST, 1922 No. 8

Heat Transmission in the Hot-Galvanizing Process

Describing the Temperature Distribution of the Process—Rate of Motion of the Sheets Through the Bath Should Vary With the Sheet Thickness If Based on the Factor of Heat Transmission.

By J. D. KELLER

PART II

FOR the purpose of mathematical investigation, the zinc bath may be considered as a heat-conducting medium of indefinitely large extent, originally at a constant temperature throughout. This assumption is permissible in view of the fact that the extent of the liquid is indeed very large in comparison with the thickness of the steel sheet (dimensions about 40 in. and 0.02 in. respectively), and that heat is continually added as required to keep the bath temperature constant.

The inter-relation of temperature, space and time in an infinite medium is expressed by a form of mathematical function which is practically identical with the Gauss probability-of-error integral — sometimes called simply the "Gauss integral" or "probability integral"—or by a combination of such functions. To get the meaning of this form of integral clearly in mind, consider first that in an infinite, homogeneous medium, originally at zero temperature throughout, a finite quantity of heat is developed at a given instant in one certain infinitesimally thin layer of the medium, see Fig. 3 (called an "instantaneous plane source").

The expression for flow of heat from this layer throughout the remainder of the medium must, of course, satisfy the fundamental Fourier equation

$$a^2 \frac{d^2T}{dx^2} = \frac{dT}{dt} \qquad \ldots\ldots\ldots\ldots(2$$

and the corresponding equation * connecting temperature with time and space is

$$T = \frac{C_1}{\sqrt{\pi}} \cdot \frac{1}{\sqrt{4a^2t}} \cdot e^{-\frac{x^2}{4a^2t}} \qquad \ldots\ldots\ldots\ldots(3$$

T being the temperature at distance **x** from the layer, after time **t** has elapsed from the beginning of the heat flow. **e** is the number 2.718—, the base of Napierian logarithms. The factor a^2 is a constant, called the "diffusivity," which depends upon the properties of the material. It is equal to conductivity λ divided by the product of specific heat **c** times density **w**; or

$a^2 = \frac{\lambda}{w.\,c}$. C_1 is a constant determined by the quantity of heat developed.

If, instead of being confined to an infinitesimally thin layer, the heat is distributed initially in some arbitrary mode through a section of the medium of finite thickness, then the temperature equation may be arrived at by considering the initial temperature-space curve as built up of a series of curves of contiguous infinitesimal layers (see Fig. 4), and similarly the temperature-space curve for any subsequent time is built up of the sum of the superimposed curves of the individual layers. If the initial temperature distribution can be expressed as a function of the space position, or $T_0 = F\,(E)$, then the temperature distribution for any subsequent time **t** is given by the summation

$$T = \frac{1}{\sqrt{\pi}} \cdot \frac{1}{\sqrt{4a^2t}} \int_{-\infty}^{+\infty} F\,(E)\,.\,e^{\frac{-(E-x)^2}{4a^2t}}\,.\,dE \qquad \ldots\ldots\ldots\ldots\ldots\ldots(4$$

This can be simplified by substituting

$$\beta = \frac{E-x}{2a\sqrt{t}}, \text{ or } E = x + 2a\sqrt{t}\,.\,\beta$$

which gives

$$T = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{+\infty} F\,(x + 2a\sqrt{t}\,.\,\beta)\,.\,e^{-\beta^2}\,d\beta \ldots\ldots(5$$

If the initial temperature is constant, independent of **x**, as in the present case, then $F\,(x + 2a\sqrt{t}\,.\,\beta) = C$ and

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*Grober, Grundgesetze der Warmeleitung.

$$T_x = C \cdot \frac{2}{\sqrt{\pi}} \int_0^{z} e^{-B^2} \cdot d\beta$$

The last part of this expression is simply the probability integral, which will in what follows be written G(z), meaning the expression

$$\frac{2}{\sqrt{\pi}} \int_{\beta=0}^{\beta=B^2} e \cdot d\beta.$$

The values of this integral, for various values of the argument **z**, may be found in treatises on theory of probabilities.

If the heat conducting medium is of the same homogeneous material throughout, as for instance in the case of a slab of hot steel inserted into a space between the parallel ends of two long steel shafts at zero temperature, then the problem can be solved † without great difficulty by splitting the integral into three parts, thus:

$$T = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{a} 0 \cdot e^{-\beta^2} \cdot d\beta + \frac{1}{\sqrt{\pi}} \int_{a}^{b} T_0 \cdot e^{-\beta^2} \cdot d\beta + \frac{1}{\sqrt{\pi}} \int_{b}^{+\infty} 0 \cdot e^{-\beta^2} \cdot d\beta, \text{ or } T = \frac{T_0}{\sqrt{\pi}} \int_{a}^{\beta} e^{-\beta^2} \cdot d\beta$$

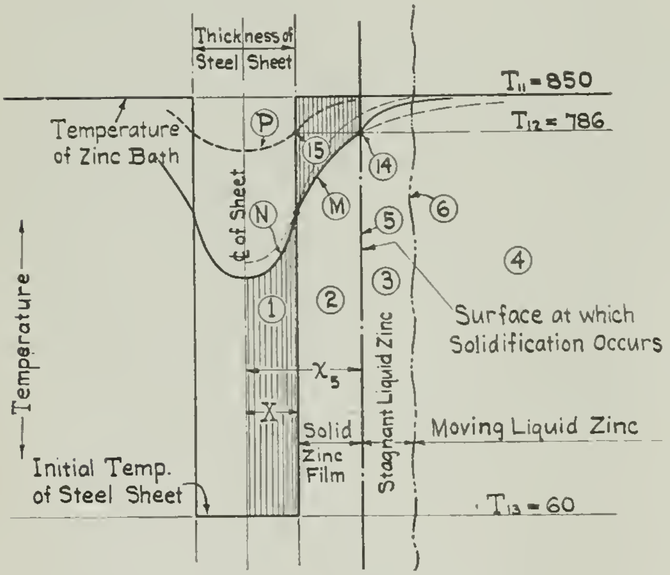

Fig. 2—Conditions during galvanizing.

For each particular evaluation of the integral, **x** and t are constant, and **E** is the variable of integration. This means that the limits **a** and **b** must be the values of β corresponding to $E = -X$ and $E = +X$. Substituting in the definitive equation $\beta = \frac{E - x}{2a\sqrt{t}}$ gives $a = \frac{-X - x}{2a\sqrt{t}}$ and $a = \frac{+X - x}{2a\sqrt{t}}$. The temperature-space-time equation is

$$T = \frac{T_0}{\sqrt{\pi}} \left[\int_{\beta=0}^{\beta=\left(\frac{X-x}{2a\sqrt{t}}\right)} e^{-\beta^2} \cdot d\beta - \int_{\beta=0}^{\beta=\left(\frac{-X-x}{2a\sqrt{t}}\right)} e^{-\beta^2} \cdot d\beta \right] \text{..........(6}$$

Corresponding curves are shown in Fig. 4.

While this solution, applying to a homogeneous medium, is fairly simple, matters become much more complicated when a medium composed of layers of different materials must be dealt with. In the galvanizing process, each of the four layers shown in Fig. 2 has its own special diffusivity **a^2** and conductivity λ, different from those of the other layers. An additional complicating factor, of great importance, is the transformation of latent heat into sensible heat, and vice versa, at the "freezing" or melting boundary plane (indicated by [5] in Fig. 2), as the layer (2) thickens or shrinks. The temperature equation could not be expressed by one Gauss integral alone, but would have to be built up of a combination of such integrals. The extreme mathematical complications have prevented a solution being reached. A problem resembling the present one in some respects—that of determining the penetration of the frost boundary into moist earth—was solved by Neumann,* but in the solution only two layers or sections of different substances were dealt with, and the temperature of one surface was considered as being held constant at all times. No such simplifications can be introduced in the present case.

Without attempting a rigorous mathematical solution expressing the time-space-temperature variation, it is possible by considering the extreme or limiting conditions to arrive at quite definite results as respects time requirement for heating, and temperature inequalities inside the steel sheet.

In Neumann's solution, referred to above, it was found that the distance of penetration of the frost-boundary is proportional to the square root of the elapsed time, this apparently holding true regardless of the relation between conductivity, latent heat, and specific heats of the different materials. It will be of interest to study first whether any such relation can be deduced in the present case, between time and distance through which the solidification or melting surface—(5) in Fig. 3—has moved from its starting plane. As this surface must maintain a constant temperature—that of melting zinc—its motion might be expected to coincide with that of a constant temperature plane expressed by some equation of unknown constants but of the general form of eq. (3 or (6. Considering first, for simplicity, eq. (3, and denoting any constant temperature T by C_2, the operations of transposition and squaring give

$$\left(\frac{C_2}{C_1}\right)^2 \cdot \pi \cdot 4a^2t = e^{\frac{-2x^2}{4a^2t}}$$

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†Ingersoll and Zobel, Mathematical Theory of Heat Conduction, p. 70.

*See Riemann-Weber, Partielle Diff. Gleich.

Taking logarithms of both sides, to base e, gives

$$\log_e \left(\frac{C_2}{C_1}\right)^2 . \pi . 4a^2t = -\frac{x^2}{2a^2t}$$

Writing instead of $\left(\frac{C}{C_1}\right)^2 . \pi . 4a^2$, the expression $\frac{C_3}{e}$, gives

$$x = \sqrt{-2a^2t . \log \left(\frac{C_3t}{e}\right)}$$

$$\text{or } x = \sqrt{-C_4t . \log \left(\frac{C_3t}{e}\right)} \ldots\ldots\ldots\ldots (7$$

A brief study of this expression shows that the distance **x** of the constant temperature plane from its starting point increases rapidly at first, reaches a maximum when $t = \frac{1}{C_3}$, then begins to decrease. The motion of one such constant-temperature plane is indicated in Fig. 3 by the series of points 1, 2, 3, 4, 5. At time $t = \frac{e}{C_3}$, the plane has come back to its starting point.

Extending the investigation to the case of a layer of finite thickness, equation (6, the expression for the motion of the constant-temperature plane is found to be very similar to that of the preceding case. It has, however, an additional term which takes care of the fact that the motion now starts, not at the origin, but at the surfaces of contact of the finite with the infinite sections. The equation for this case is

$$x = \sqrt{X^2 - 2a^2t . \log_e \left[\left(\frac{T}{T_o . 4X}\right)^2 . \pi . 4a^2t\right]} \text{ or}$$

$$x = \sqrt{X^2 - C_4t . \log \left(\frac{C_5 . t}{e}\right)} \ldots\ldots\ldots\ldots (8$$

in which **x** is the distance of the constant-temperature plane from the origin, taken at the center of the finite section; **X** is half the thickness of that section; C_4 and C_5 are constants depending upon the initial temperature T_o, the constant temperature **T** and the thermal properties of the material; and the other symbols have the same meaning as above. The form of curve corresponding to equation (8 is shown by the broken line (D) in Fig. 5.

This equation expresses the motion of a constant-temperature plane in a medium which is homogeneous throughout and is free from latent heat or heat-of-fusion effects. Whether it will apply in the more complicated case under consideration depends at least in part upon the boundary conditions. Referring to Fig. 2, temperature T_{12} is constant and equal to the melting point of zinc, 786 deg. F. * T_{11} is also constant, or at any rate its variation is negligibly small, because heat transmission occurs with extreme rapidity in the violently agitated zinc bath (4). Finally, there is no reason why the resistance of film (3) should vary, if rate of motion of the sheet through the bath is constant. The conclusion from these considerations is that the rate of heat transmission must also be constant. Heat is transferred from the bath (4) through film (3) at an unvarying rate, entirely independent of the rate at which heat is being taken up by the steel sheet. The film of zinc acts in effect as a heat-reservoir, first giving out and later absorbing heat as required to make up the difference between rate of supply from the bath and rate of absorption by the sheet. At the first contact, the sheet is taking up heat at an enormous rate, and the zinc must solidify quickly in order to evolve the make-up heat. Later, the sheet absorbs heat less quickly than it is supplied, and the melting of the zinc takes up the excess. Mathematically expressed, this takes the form of the equation

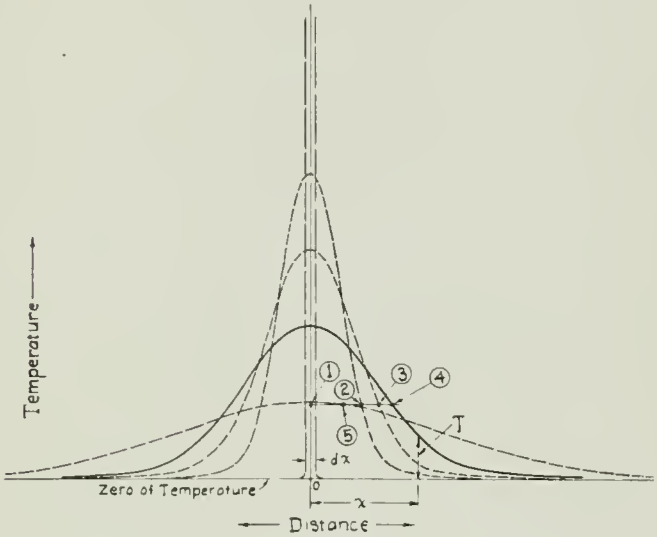

Fig. 3—Flow of heat from an infinitesimal layer.

$$W_2 . Q . \frac{dx}{dt} = \lambda_2 . \frac{dT_2}{dx} - k . (T_{11} - T_{12}) \ldots (9$$

applying to the boundary surface (5), Fig. 2 . w_2 is the density of the zinc, **Q** its heat of fusion, and λ_2 its conductivity; k is the coefficient of heat transmission through film (3).

As stated above, the relative effect of the various factors can be brought out most clearly by carrying conditions to extremes. First, suppose that heat of fusion is finite, specific heat is finite, but that the conductivities of the steel sheet and of the solid zinc film are indefinitely large, in comparison with the rate of heat input. Then the temperatures would equalize almost instantaneously in the interior of the sheet and in the zinc film; the surface (5) would move outward with practically infinite velocity to its maximum distance, after which the film (2) would melt off at a uniform rate. This is indicated by the dot-dash curve (F) in Fig. 5.

The maximum thickness x_5 of the solid film, represented by the point (A) in that figure, can be determined from the consideration that (under these particular conditions) all of the heat absorbed by the steel sheet must come from the solidification and cooling of the zinc film (2), or

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*If the zinc bath has become contaminated by absorbing much iron, the fusion temperature is higher.

$$w_1 . c_1 . X . (T_{12} - T_{13}) = (x_5 - X) . w_2 . [Q + C_2 . (T_{11} - T_{12})].$$

Substitution of numerical values gives

$$\text{limit } \left[\frac{(x_5 - X)}{2X}\right] = \frac{488 \times 0.133 \times (786 - 60)}{2 \times 430 \times [0.105 \times (850 - 786) + 50]} = 0.965$$

The thickness of the solid zinc film on either side could never exceed 96½ per cent of the thickness of the steel sheet. Actually it must be considerably less than that, first, because the conductivity is not infinite, and not quite so much heat is absorbed by the steel as would be the case if its temperature rose at once throughout to that of melting zinc; second, because film (2) does not attain its maximum thickness instantly, but requires a finite time interval, during which heat flows in through surface (5), so that less heat need be furnished by solidification of zinc.

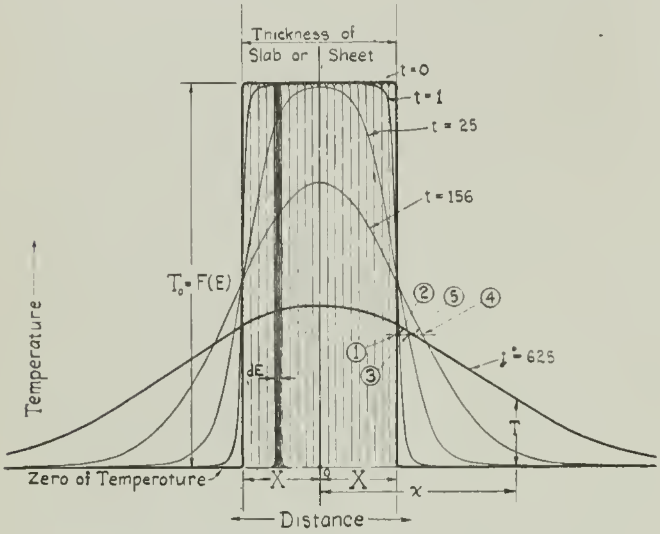

Fig. 4—Flow of heat from a slab of finite thickness.

At the other extreme, suppose that conductivity and specific heat are finite, but heat of fusion is zero. Then the curve of motion of the surface (5) would be of the form expressed by equation (8 and shown by the broken line (D) in Fig. 5.

The true curve of motion will evidently have a form intermediate between the two, and nearer to the one or the other as the influence of conductivity or of heat-of-fusion varies in comparison to rate of heat input. The solid line (E) of Fig. 5 represents one such curve.

Considering again equation (9 as applied to the conditions of the first limiting curve, (F) of Fig. 5, it is evident that as the second term drops out—the steel sheet in this case being at uniform temperature throughout and absorbing no heat after the peak (A) of the motion curve is passed—the slope of curve (F) would be

$$\frac{dx}{dt} = \frac{- K . (T_{11} - T_{12})}{W_2 . Q} = \text{constant.}$$

The slope of curve (P) in Fig. 2, when the solid film has just disappeared, would of course be

$$\frac{dT_1}{dx} = \frac{dT_2}{dx} = \text{zero.}$$

As applied to the second limiting curve (D) in Fig. 5, the first term of equation (9 disappears (Q = zero) and this would give

$$\frac{dT_2}{dx} = \frac{k . (T_{11} - T_{12})}{\lambda_2}.$$

At point (15) in Fig. 2, $\lambda_2 \dfrac{dT_2}{dx} = \lambda_1 \dfrac{dT_1}{dx}$, hence $\dfrac{dT_1}{dx}$ would equal $\dfrac{k . (T_{11} - T_{12})}{\lambda_1}$.

In the actual case, to which some motion curve of the form of (E) in Fig. 5 applies, the value of $\dfrac{dT_1}{dx}$ will lie somewhere between these limits. That is to say, the slope of the temperature-space curve at the surface of the steel sheet and at the instant when the solid zinc film has just disappeared (point [15] in Fig. 2) be greater than zero and less than

$$\frac{dT_1}{dx} = \frac{k . (T_{11} - T_{12})}{\lambda_1} \qquad \text{..........(10}$$

This furnishes a means of finding the limiting temperature difference inside the steel sheet. As stated above, the equation of curves (M), (N) and (P) of Fig. 2 are Gauss integrals; however, the constants are unknown. Curve (P) for any one time may be expressed thus:

$$T_1 = \tfrac{1}{2} A_1 . G [B_1 . (X - x)] - \tfrac{1}{2} A_1 . G [B_1 . (-X - x)] \qquad \text{.........(11}$$

Differentiation gives the slope as

$$\frac{dT_1}{dx} = \tfrac{1}{2} A_1 B_1 . \frac{2}{\sqrt{\pi}} \left[e^{-B_1^2 . (X - x)^2} - e^{-B_1^2 (-X - x)^2}\right] \qquad \text{..(12}$$

By equating (10 and (12 and substituting numerical values, the constants A_1 and B_1 may be determined. Of course they apply only for one fixed time, and equation (11 can only express the variation of temperature with space, and not with time. Substituting the constants thus found in (11, the limiting values of temperature T_1 may be found at $x = 0$, the center of the sheet.

It should be understood that the temperature toward which all parts of the system are approaching—in this case the temperature of the zinc bath—is, in these equations, taken as the zero point, merely for convenience of calculation. Whether the finite section surrounded by an infinite medium approaches the temperature of the medium from above or below that temperature, is immaterial so far as regards the form of the equations or curves. To reduce to the Fahrenheit scale, all that is required is to add 786, the temperature of melting zinc.

For example, consider a sheet of No. 24 gage, 0.025 in. thick. $X = \dfrac{0.025}{2 \times 12} = 0.00104$ ft. k will be taken as 400. Btu per square foot, degree F. and hour.

$\lambda_1 = 34$, $\lambda_2 = 65$ Btu per sq. ft. hour, deg. F. and ft. thickness. T_{11} is taken as the zero toward which all temperatures are approaching, and T_{12} is taken as $786 - 850 = -64$.

$$\frac{-400 \times 64.}{34.} = \tfrac{1}{2} A_1 \,.\, B_1 \,.\, \frac{2}{\sqrt{\pi}} \left[1 - e^{-B_1^2 \,.\, (-0.00208)^2}\right]$$

$$-64 = \tfrac{1}{2} A_1 \,.\, G\,(0) - \tfrac{1}{2} A_1 \,.\, G\,[B_1 \,.\, (-0.00208)]$$

Solving graphically, $\frac{1}{2} A_1 = -376$, $B_1 = 73$.

$$T_1 = 376 \,.\, G\,[73 \,.\, (-X - x)] - 376 \,.\, G\,[73\,(+X - x)].$$

At the center of the sheet, $T_1 = -64.5$ deg. This means that the difference of temperature between center and surface of sheet can not exceed one-half of one degree F.

This result can be checked approximately in another manner, namely by comparing with a cosine curve having the same slope at point (15). It is well known that, after heat transmission has been in progress for some time, the space-temperature curves very nearly coincide with sine or cosine curves. Differentiating the equation

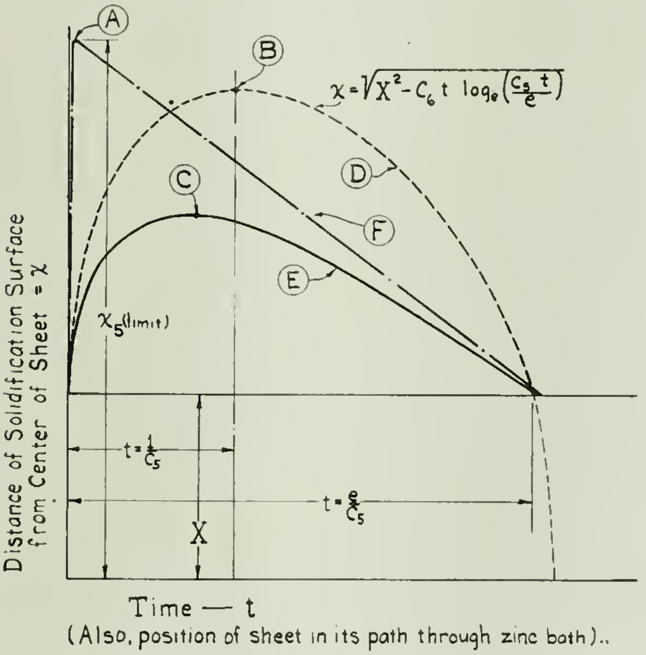
A
B
C
D
E
F
$x = \sqrt{X^2 - C_6\, t \log_e\left(\frac{C_5\, t}{e}\right)}$
x_5(limit)
$t = \frac{1}{C_5}$
$t = \frac{e}{C_5}$
X
Distance of Solidification Surface from Center of Sheet = x
Time — t
(Also, position of sheet in its path through zinc both)..

Fig. 5—Curves of motion of solidification or melting surface.

$$T = -64 - B_2 \cos\left(\frac{\pi}{2} \times \frac{X}{x}\right)$$

$$\text{gives } \frac{dT}{dx} = \frac{\pi}{2X} \,.\, B_2 \,.\, \sin\left(\frac{\pi}{2} \,.\, \frac{x}{X}\right),$$

$$\text{and for } x = X,\ \frac{dT}{dx} = \frac{\pi}{2X} \,.\, B_2.$$

But from equation (10

$$\frac{dT}{dx} = \frac{k\,(T_{11} - T_{12})}{\lambda_1} = \frac{400 \times 64}{34} = 752 \text{ deg. per foot.}$$

$$B_2 = 0.50, \text{ and } T = -64 - 0.50 \cos\left(\frac{\pi}{2} \times \frac{x}{X}\right).$$

At the center of the plate, $X = 0$, $\cos 0 = 1$, and $T = -64 - 0.50$ or the temperature of the center of the plate would be 0.50 deg. lower than that of the surface.

If the plate were No. 16 gage, 0.0625 in. thick, and if **k** remained the same, 400 Btu per sq. ft., hour and deg. F., the greatest possible temperature difference between center and surface would be 1.3 deg. F. But the thicker sheet must move more slowly through the bath, and as explained in part I, **k** would decrease to about 120. for No. 16 gage sheet. The maximum temperature difference in that case would be 0.38 deg. F.

It may be well to repeat that these are the maximum or limiting temperature differences, and that the further the curve of motion of the zinc solidification surface departs from the form of (D), Fig. 5, and the nearer it approaches (F), the less is the temperature difference in the steel sheet.

While the above mathematical treatment is far from complete, it does at least show that, for any reasonable thickness of sheet, the steel is heated practically uniformly throughout; and that the time required for the surface to reach the galvanizing temperature is practically independent of the temperature gradient in the steel, and is directly proportional to the reciprocal of the rate of heat transmission.

PYROPHOROUS BLAST FURNACE DUST

The dust collecting in the upper portions of the shafts of blast furnaces and in the filter bags of dry gas purifiers is apt to catch fire spontaneously or when disturbed. At Wissen in Westphalia it was observed that the dust heaps would begin to smoulder in a few hours or days, especially heaps of very fine dust settling at some distance from the furnace. The still finer filter bag dust, weighing only about a quarter of the coarser blast-furnace dust, was worst, and the men had to be very quick and keep the gas suction going, when exchanging the gas bags, to prevent the bags from catching fire. The investigation started at Wissen on behalf of the Blast-Furnace Section of German Iron Men, on which J. W. Gilles reported in Stahl und Eisen, of June 8, pages 884 to 891, is not complete yet; but it shows that two substances are mainly responsible. The dust contained neither metallic iron (to be removed by magnets), nor metallic zinc, nor was it rich in carbon. But it was rich in manganous oxide, and at Burbach and Neuenkirchen (Saar district), where similar trouble had been experienced, rich in ferrous oxide; both these protoxides are known to be pyrophorous. Sulphides present in the dust do not seem to be concerned in the phenomenon, nor had the potash any influence, though the whole mass might become hot when the potash absorbed moisture. When the dust is once allowed to cool under exclusion of the air, it will not catch fire readily afterwards until heated up; but old dust heaps need only be stirred up with the shovel to begin to glow. The temperature to start ignition seems to range from 167 deg. C (fresh dust) up to 120 deg. C. (old dust). When the dust is heated in the presence of air so that the carbon is burnt out, and then cooled, and reheated in a current of hydrogen or of illuminating gas, it proves highly pyrophorous. This treatment would result in the formation of protoxides of iron and manganese.

Efficient Operation of the Blast Furnace

A Great Deal Can Be Done to Improve Stove Operation by the Application of Mechanical Draft—Forced Draft Burners Can Also Be Applied to Advantage.

By T. A. PEEBLES

IT is difficult to establish standards for operation involving the combustion of fuel which can be applied to a variety of conditions. This is especially true of blast furnace operation, because of the nature and number of variables to be considered. It may be assumed, however, that a modern furnace, producing 550 tons of pig iron per day, will have a 2,000-pound coke rate and will produce about 134,000 cubic feet of dry gas per ton of pig iron produced, with a heating value of 100 Btu. per cubic foot. This quantity of gas is considerably in excess of the amount required for heating the stove and producing the necessary power and auxiliary steam, so that the isolated blast furnace is not interested in the economical use of gas. This fact probably accounts for some of the inefficient practices that have developed in the past, even at furnaces so located that their excess gas might not be used in other processes of steel manufacture.

At many of the older furnaces 30 per cent of the gas generated will be used for heating the stoves and 35 per cent for auxiliary power, blowing, direct steam, etc., leaving 35 per cent available for outside power. A boiler plant operating at 60 per cent efficiency can develop 1925 hp. continuously from this quantity of gas. It has been assumed that the 35 per cent of the total gas which goes for blowing, auxiliary power, etc., is also used for producing steam under boilers, operating at an efficiency of 60 per cent.

It has been proven possible to operate blast furnace gas fired boilers at an operating efficiency of 80 per cent and if the 35 per cent of total gas used for blowing and auxiliary power had been used to generate steam at 80 per cent efficiency, instead of 60 per cent, the proportion of gas thus required would be reduced from 35 per cent to 26.25 per cent. At the same time more efficient combustion at the stove will reduce the gas required from 30 per cent of the total to 25 per cent or slightly less. The total gas required at the blast furnace plant is therefore 51.25 per cent, leaving 48.75 per cent available for outside power, which at 80 per cent efficiency will produce 3,575 boiler horsepower continuously, an increase of 1,650 horsepower over old practice.

This represents a very substantial saving, even in a large steel mill, where it is customary to deal in large quantities, and justifies a careful study of the problem.

It is first necessary to render as much gas available for boilers as possible, by most efficient utilization of that required to heat the stoves. Present practice consists of delivering the gas under whatever pressure exists in the main, drawing in the air for combustion by induction of the inflowing gas, and by the suction in the first pass of the stove. The burners are usually set to provide a sufficient quantity of gas when the line pressure is low, with the result that during times of normal or high pressure a considerable excess is being used. The variations in gas delivered also effects, to a certain extent, the amount of air supplied for combustion, but due to the variations of draft inside the stoves the introduction of air is not proportioned in accordance with gas delivered. Under such conditions, the most efficient combustion is impossible and an unnecessary quantity of gas is required at the stoves.

A great deal can be done to improve stove operation by the application of mechanical draft. Forced draft applied to the delivery of combustion air can be automatically regulated in such a manner that the correct quantity of air can be delivered in accordance with the quantity of gas being burned, and this correct proportion between air and gas will not be disturbed by variations in furnace draft. This can be accomplished by designing a burner which will give the correct proportions between air and gas, when the relative pressures are equal. Automatic regulation can then be applied to maintain the air pressure equal to the gas pressure and the correct heats of air and gas will be delivered, regardless of variations of draft inside the stove.

The application of induced draft to stove operation makes possible additional improvement in economy. The temperature of gases leaving a cold stove will be approximately 300 deg. F. and the draft available for removing products of combustion is, therefore, eliminated. As the stove heats up the draft capacity increases until a temperature of about 600 deg. F. is reached. When the temperature goes above this point the weights of products of combustion which the chimney can handle will decrease, because the density of the products of combustion decrease more rapidly than the velocity increases.

The application of induced draft makes it possible to overcome the difficulty and at the same time makes possible the use of a suitably designed recuperator. A hot stove will discharge the products of combustion at temperatures as high as 1100 deg. F. and a large amount of heat is lost. A suitably designed recuperator can be employed to absorb a substantial quantity of heat from the escaping gases, which can be used for preheating the combustion air, thereby improving the economy of the entire cycle and making possible higher stove temperatures, when desired.

The next step in the efficient utilization of blast furnace gas is to provide boilers properly designed for peculiar services with the most efficient type of burners. The boilers should have a long gas travel, in contact with the tubes, because the furnace temperatures are comparatively low and a large weight of gas is required per horsepower.

Forced draft burners can also be applied to advantage. There are two different types available:

First—Burners have definite areas of air and gas

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*Mr. Peebles is with the Hagan Corporation, Pittsburgh, Pa.

passages. In some cases equal areas are employed and the correct relation between air and gas pressure required for correct proportions are maintained automatically. The gas pressure is allowed to vary in accordance with the furnace operation and the air pressure automatically maintains the predetermined relation between air pressure and gas pressure. If unequal air and gas pressures are employed, it is important that uniform furnace draft be automatically maintained, because a variation in furnace draft has a different effect on the rate of flow of the air and gas, if they are delivered under different pressures. This objection can be overcome by employing burners designed to give the proper relation between air and gas, when the two pressures are equal. In this case a change in furnace draft effects both air flow and gas flow equally, and will not disturb the established proportions.

Second—The gas burners at the boilers may be designed to act as pressure regulators on the entire gas system. Each burner contains a damper for the control of air supply, and these dampers are automatically controlled from variations in gas pressure. A predetermined gas pressure is established, which it is desired to maintain automatically means provided for delivering the necessary quantity of air at a pressure equal to the gas pressure. The dampers in each boiler controlling the air supply and gas supply are operated in accordance with variations in gas pressure. An increase in gas pressure results in an increased opening of air and gas dampers, thereby maintaining an increased flow of both air and gas between them, in the correct proportions. On the other hand, a decrease in gas pressure results in a reduced opening of these dampers and the tendency, therefore, is to maintain constant gas pressure in the mains and to secure most efficient combustion of all the gases available for the boilers.

The burning of blast furnace gas has not kept pace with the development in the efficient use of other fuel, but there are many indications that blast furnace operators are prepared to give this matter the attention which its importance justifies. Suitable burners for properly proportioning air and gas, as well as automatic devices for their regulation, have been developed, and are in successful operation in a number of plants. These plants show better overall economy than plants operating without this equipment, the difference being much more than is necessary to justify the cost of installation.

Effect of Sulphur on Rivet Steel

Discussion of a Committee's Report On Effect of Sulphur On Rivet Steel, American Society For Testing Materials, June 28, 1922

By J. S. UNGER

FOR more than 40 years the question of the effect of Sulphur in steel has attracted the attention of metallurgists. Much study has been given to this subject, extending so far as to include the several chemical forms or combinations in which it exists, particularly in cast iron.

Within a period of 20 years, the tonnage of steel made by the two principal processes, the Bessemer and the Basic Open Hearth, has undergone a great change. In 1900 about 65% of the total tonnage was Bessemer—in 1920, 25%.

With the change in Processes came a change in the sulphur content in steel, the average sulphur in Bessemer steel being at least .065, against .040 in the basic open hearth. Structures of all kinds built from 20 to 40 years ago of Bessemer steel, are still in service today, being one of the best evidences that steel may contain a considerably higher percentage of sulphur than is permissible in present basic open hearth specifications, and still give years of excellent service.

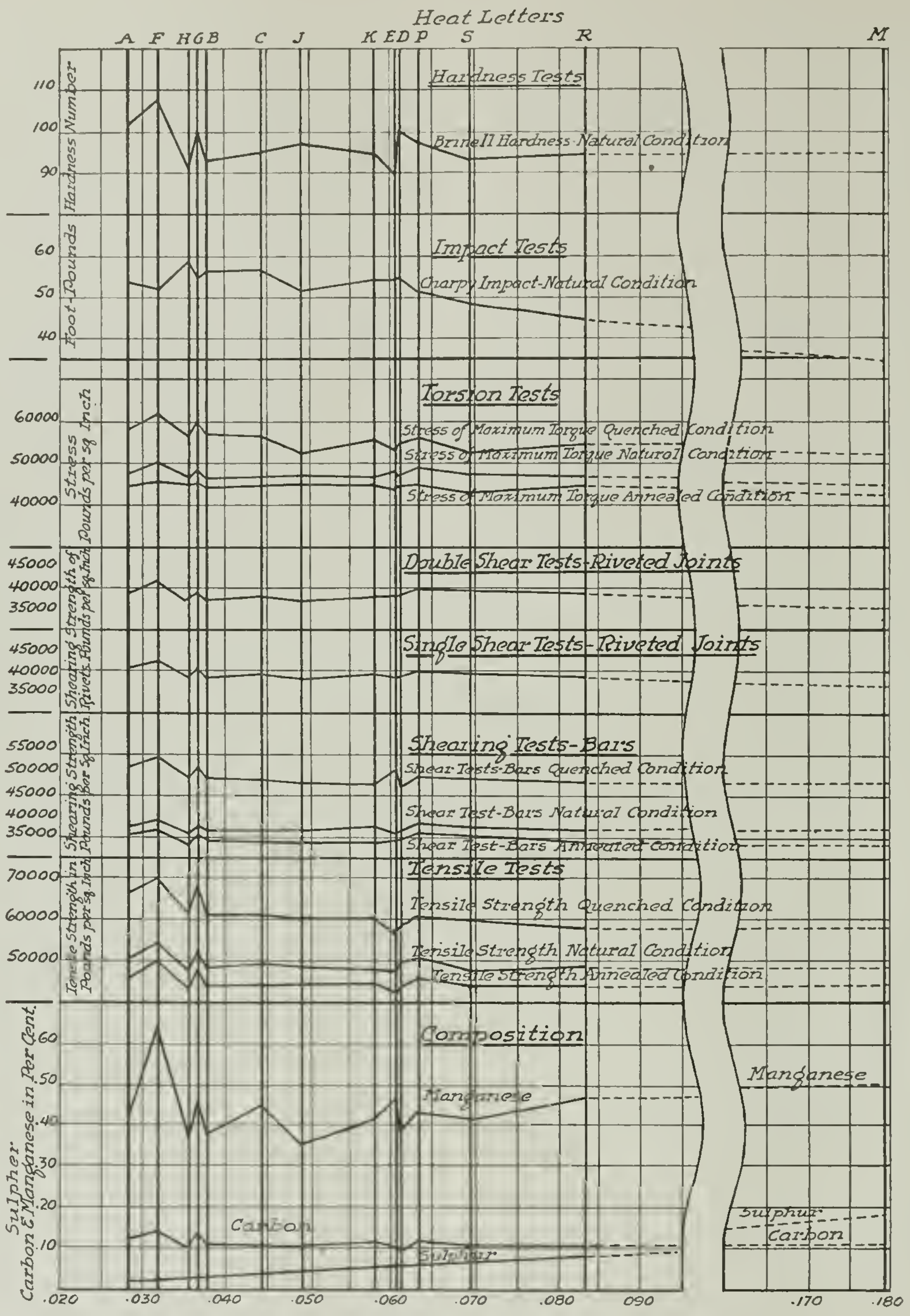
Additional evidence is found by making a study of soft, medium and hard steel parts, which have worn out in service, giving a good life, and which in many cases have contained more than .065 sulphur. On the other hand, equally convincing evidence is found for the same kinds of steels failing after a short time in similar service, in which the sulphur has been under .040. Evidence of the above kind is enough to make one hesitate in forming an opinion whether a reasonable amount of sulphur, say under .100, is detrimental or otherwise. These facts conflict with the generally accepted opinion that steel is of poor quality and should not be used for any important work, unless it be low in sulphur. I sincerely hope the committee will give this angle of their work serious consideration in their future studies.

In discussing the committee's preliminary report, I have copied graphs from their report, combining a number of their graphs on a single sheet and inserting a line for sulphur in order that it may be more easily and quickly comprehended.

In this chart, I have shown the composition curves for carbon and manganese at the bottom, adding a line for the sulphur content. Since ordinates and abscissas are in percentages of sulphur, the line for sulphur becomes a gradually rising straight line.

The effect of the Carbon and Manganese in the several heats is clearly shown by the approximate parallelism of the composition curves with those representing the Tensile, Shearing, Torsion, Impact and Hardness curves. All the curves for the physical properties are not shown as there is not sufficient space on the chart.

The striking thing in the chart seems to be that changes in the Carbon and Manganese content are immediately reflected by similar changes in the physical properties of the several heats with little, if any, change due to the increasing sulphur. It is almost impossible to make a number of heats of steel containing exactly the same percentage of carbon and manganese. Since this is true, it is practically impossible to determine the effect of sulphur if other variables in composition exist in the steel.



Comparison of Composition Curves with Curves for Various Tests.
"Discussion:- Effects of Sulphur on Rivet Steel."

Fig. 1.

In studying this same problem during 1915, I believed it best to use the same heat of steel, but to vary the sulphur content in the individual ingots of the heat. My results were given in full in a paper before the Society of Automotive Engineers, in January, 1916, and later in a paper before the American Boiler Manufacturers, in June, 1916.

Many persons are inclined to believe that sulphur added to steel does not have the same effect as residual sulphur remaining in the steel, but it is surprising how closely my results, obtained by added sulphur, check the results of the committee's work with residual sulphur, when allowances are made for the effects of the variations in the carbon and manganese in the several heats.

The committee's work was confined to rivet steel, but this same quality steel is used in making wire products, tubular products and sheets. The specifications for such products specifies the composition and sometimes calls for tensile tests and bending tests. The fitness of the steel is determined by the working of steel during fabrication and by such shop tests as flattening, bending, hydrostatic or heading tests. On pages 9, 10, 11 and 23 of the report, some shop tests were made, showing very little differences among the steels. These are some of the commercial tests employed by the user to show whether the steel is of good quality, yet the committee, beyond stating what was done have not made any comment on the quality. Instead physical or mechanical tests of many kinds were made, very few of which are ever regularly used in the arts, and the graphs presented to show the quality.

I have examined the complaints or claims for rivet steels covering a period from 1911 to 1922 or 11 years. They show the following percentages:

For Quality	
Mixed steel, and Tensile Strength	15%
For Surface	
Mechanical Defects, Seams, Pipe, Split Heads	28%
For Rolling	
Out of round—Variation in Size	6%
For High Sulphur	51%
Total	100%

This table shows that more than one-half of the complaints were due to high sulphur, in most cases causing the rejection of the steel without any effort being made on the part of the user by shop or service tests to see if the steel was really bad or unfit for use.

The committee has refrained from drawing conclusions from their work. The graphs are not easily understood by the layman. Considerable time has elapsed since the work was begun. Probably a much longer time will be needed for the study of the medium and harder varieties of steel. In the meantime, much commercially good steel is being thrown away. The producer and consumer are awaiting the verdict.

I ask the committee to hasten their work, drawing conclusions as they proceed and completing the work at an early date. This will be of great benefit to our society, settling, partially at least, a controversy of many years standing.

Economically Burning Liquid Fuel

Factors Affecting the Use of Air in Oil Burning With Comparison of Cost.

By W. C. BUELL, JR.
Buell, Scheib and Mueller, Inc., Pittsburgh, Pa.

THE question of the advantages to be found in burning liquid fuels with air under various pressures has been the subject of considerable discussion, but little has been written on the subject and figures of comparative performance are entirely lacking.

This subject is one of sufficient importance for a careful analytical discussion, as the summary at the end of this paper will show. As nearly every industry burns more or less oil or tar the subject is one of quite general interest, and a consideration of the summary of the analysis made hereafter will clearly show that it is possible to waste a large amount of money in purchasing a selected fuel or in using air that must be reduced in pressure to meet the requirements of combustion.

An examination of the oil burning systems offered for industrial heating practice will indicate that there are three general types of oil burners classified on a basis of air pressures at the source of supply from which they operate, and somewhat along the following line:

(a) Those burners employing so-called "volume" air which is moved by high speed fan-blowers and delivered to the burners at pressure from 4 to 10 or 12 ounces.

(b) Those burners operating on so-called "positive" air which is delivered to the burners by displacement or turbine type machines and occasionally by very high speed centrifugal fans, at pressures ranging from 12 ounces to 2 pounds.

(c) The burners utilizing "high pressure" air which is delivered to the burners from compressor lines in which pressures ordinarily run from 50 to 60 or 100 pounds gauge.

Each of the three foregoing systems has its advocates and it is usual for the manufacturers of oil burning equipment to follow the lines of least resistance when making recommendations and to propose equipment using the air pressure which is favored by the customer rather than to stand on sound engineering principles and to recommend equipment operating under the best economic conditions.

It is the writer's purpose to discuss at some length all of the factors affecting the use of air in oil burning under the above classifications, but with reference to Class A equipment it should be understood that burners operating on the low pressures of this classification cannot depend on the air to atomize the oil, but must of necessity use a mechanical system, in which the oil fuel is atomized by the static oil pressure forcing the oil fuel through very small orifices in the form of a fine spray which the low velocity air can easily pick up.

The use of this system is limited to oil which is very fluid and very clean; viscous or dirty oils will cause partial or complete cessation of operation and with the necessity for the conservation of the petroleum resources of the country clearly before us, it is an unnecessary

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*Abstract of paper presented before Engineers' Society of Western Pennsylvania.

waste of the natural lubricating and potential chemical reserves of the country to use as fuel selected distillates of high Baume gravity, the only kind which can be used successfully in the mechanical system as applied to furnace practice. As a matter of fact, in this day and age only residue and heavy fuel oils should be considered as fuels.

A few manufacturers still offer "volume" systems. The more progressive propose the "positive" system, while quite a number advocate the use of "high pressure" systems, while plant engineers are prone to specify "100 pound air is available and will be used."

Air Velocity at Various Pressures.

A study of the dynamic head or velocity coming from the static air pressure when discharged against the atmosphere (which throughout this paper is assumed to be 14.7 pounds pressure absolute at 70 deg. F.) will show that at one inch water pressure the velocity will be 70 feet per second, at one pound the velocity will be 352 feet per second, and at four pounds over 700 feet per second. If we calculate still further on the basis that four times the pressure will double the velocity we will find that at 64 pounds gauge pressure the velocity will be approximately 2,800 feet per second. Of course, at the common 80 pounds gauge pressure for compressed air delivery the velocity will naturally be still higher.

It must not be assumed that air passes into the burner setting at anything like the velocities that are a function of high pressure air. Velocities are very much reduced by permitting the air to expand through the controlling valves and it is the writer's opinion, based on observation, that combustion can never be sustained when air enters the burner setting in excess of approximately 600 feet per second, which is the equivalent dynamic head coming from approximately 3 pounds gauge static pressure; in ordinary combustion practice, velocities must be not greater than 100 feet per second 6 or 8 inches ahead of the burner nozzle if good results are to be secured.

It will be shown that the comparative cost of compressing air at 2 pounds, which produces an ideal combustion condition, is somewhat higher than the cost of compressing air initially to approximately 15 pounds gauge, and while air is seldom furnished by machines delivering it at an initial pressure of 15 pounds, the use of air initially compressed to 15 pounds offers interesting cost possibilities under certain installation conditions.

Functions of Velocity.

In oil burning practice air velocity has two general functions: First, to atomize or shred the oil fuel into minute globules, thus increasing the surface exposed to the volatilizing effect of the air stream and placing the oil in a gaseous or semi-gaseous form in order to burn it as rapidly as possible; and, second, to induce the greatest possible amount of atmospheric air which may be secured through aspirator action in the throat of the setting and which may be frequently greatly increased by proper setting and burner design.

Velocities for Atomizing.

It will be conceded that in burning oil a certain standard practice must be established, based on good engineering principles, in order to secure the most satisfactory operation and this is especially true where it is desired to use the heavier grades of oil.

According to the writer's experience, the general statement can be made that if oil reaches the burner tip at a viscosity of not more than 300 seconds on the Saybolt viscosimeter satisfactory atomizing will take place if the air column meets the oil at pressures from 12 ounces to 15 pounds.

Saybolt seconds divided by 30 will give the ratio fuel flow as compared to water and therefore, 300 Sa bolt seconds means that oil may be used that is 10 tim as viscous as water under equal conditions (tempe tures excepted); in other words, a volume of oil th requires 10 times the amount of time required for equal volume of water in the apparatus to flow through a given orifice under similar conditions will have a viscosity 10 times that of water.

Heating the oil is usual practice to reduce the viscosity of fuels that at ordinary temperatures are too viscous to atomize by air action. With all commerci oils offered for fuel today the viscosity of 300 Saybo seconds will be secured at temperatures under 250 de F., and this seems to mark the maximum working lin its of oil heating, as at high temperature oils may some extent decompose, possibly gasifying to some d gree and also have a tendency to deposit solid carbo therefore, it may be safely said that 300 seconds Sa bolt viscosity is the maximum limit allowable in burning. Therefore, in designing oil burning systems, the air system should be predicated for a fuel having a fluidity of 300 Saybolt seconds.

Velocity Found in Combustion.

On this subject a number of assumptions must be made. Some research has been done, notably on p hydrogen, to determine the rate of flame propagat and with air at atmospheric temperature and const pressure it would seem that the speed of back fire hydrogen is approximately 14 feet per second. This means that if hydrogen is mixed in proportion with column of air having a velocity in excess of 14 feet per second the air velocity will blow the point of combustion away from the point of mixing, while if velocity falls below the rate of 14 feet per second the hydrogen air mixture will burn back to the point of mixing.

Little work has been done or at least published the subject of rate of combustion of the hydrocarbo the information is at the best unreliable and, like th figures for hydrogen, the results apply merely to laboratory practice. From such data as the writer has been able to collect and from observation in many years of combustion research work he believes that the speed of back fire in Pittsburgh natural gas is about 8 feet per second with air in proper proportion and that in the case of fuel oil it is considerably lower and probably in the neighborhood of 5 feet per second, these results, of course, being found at constant pressure and atmospheric air temperatures.

Assuming the writer's figures to form a basis for consideration of the combustion of commercial fuels, it may, therefore, be stated that an air oil mixture entering a cold combustion chamber with a speed in excess of 5 feet per second must be broken down to approximately that figure (at least) before combustion will be sustained.

A simple phenomenon which will illustrate this is very frequently observed when endeavoring to light an air oil mixture in a cold furnace. The air oil mixture travels into the furnace perhaps several feet before combustion is sustained at all, then often very poorly, but as the combustion chamber heats up, radiant heat from the setting is focused on the entering an oil column, and as the mixture preheats, the point of combustion works back until combustion is sustained in proximity to the burner tip. As a further example, it is quite often observed that in order to sustain combustion at all in a cold furnace a baffle brick must be placed a foot or so ahead of the burner upon which the air oil column impinges, breaking up the velocity of a part of the column at least, practically to zero. When starting it is hard to maintain satisfactory combustion, but as the baffle brick heats up, the heat of the brick supports the combustion of the air oil mixture. A baffle brick used as described is an indication of faulty condition in the oil burner or setting.

It must not be assumed that it will be desirable to introduce the air oil mixture at a velocity as low as the speed of back fire. Excessively low velocities in the mixture, when the furnace is hot, have a tendency to make the resulting combustion altogether too "soft." As a matter of fact, it is customary to introduce the mixtures with a velocity of perhaps 60 to 80 feet per second, which, while it may make the lighting of a cold furnace somewhat troublesome, will permit a very excellent combustion condition. After a burner setting has become sufficiently heated to radiate heat to the air oil column, and the air oil column is heated beyond the ignition point of the mixture (which is relatively low and probably in the neighborhood of 700 deg. F.), combustion takes place and is sustained readily with velocities up to approximately 100 or 120 feet per second; these are, however, unduly high and usually produce the severe "blow piping" action which causes rapid failure of the refractories on which the flame may impinge. It is only by preheating the air oil column to a considerable degree that combustion is sustained with desirable velocities, which from the writer's observation appear to be about 65 feet per second. From the foregoing it will be seen that energy expended in compressing air to a point that will produce velocities much above 1,000 feet per second is a considerable waste of money.

Reduction of Velocity.

In oil burning practice the velocity of the entering air must be broken down to the combustion speed equilibrium as quickly as possible, and at a predetermined distance from the burner tip in order to secure the liberation of the heat within the most desirable space.

This is accomplished in several ways, singly or in combination as follows.

The expenditure of dynamic energy in the mechanical air by atomizing or shredding the fuel is one means of reducing the velocity. The expenditure of energy in inducing atmospheric air is another. Friction in the metal burner funnel and fire brick setting has a material reducing effect, as does the expansion of air in the burner setting and the impingement of air oil mixture on the surface of the brick work. A sudden change of direction of flow has a great reducing effect, but possibly the expansion of the air oil column within the setting and the combustion chamber is the greatest single factor tending to reduce velocities, it being assumed that furnace pressures are but slightly above the atmosphere.

Quantities of Air Required for Burning Fuel Oil.

The amount of air required for combustion of fuel oil varies from 1,250 cu. ft. per gallon in the case of a light oil approaching kerosene, to 1,700 cu. ft. per gallon with heavy oil approaching 10 deg. Baume, or from 192 to 220 cu. ft. per pound. Usually air in excess of that required for perfect combustion is present in the combustive reaction and excess air in itself is the source of one of the greatest fuel wastes. To a marked degree the use of excess air may be eliminated by proper engineering, the selection of the air mover and the design of the air distributing system, the burners and the setting.

In nearly every case, excepting only a few special heating operations, it may be taken that perfect combustion produces the most desirable furnace atmosphere and anything that will assist in securing approximately perfect combustion will produce a saving of considerable magnitude.

It should be understood that perfect combustion is never accomplished commercially except instantaneously, as there are many variables affecting the reaction which are continually acting to change the proportions of air and fuel, but excess air to the extent of 5 or 10 per cent should mark a maximum in liquid fuel practice, and this may easily be accomplished with a properly installed system.

Oil Burning Practice.

If the opening through the furnace wall through which the combustive mixture of oil and air passes is correctly designed and if the flues and other passages within the furnace are so proportioned that no undue pressure is set up within the furnace a considerable amount of atmospheric air may be induced by the action of the air from the mechanical compressor and thus the size of the blowing apparatus may be held relatively small.

In the case of "volume" air as defined in the "A" classification, the best conditions that may be secured average about two parts blower air to one part atmospheric air induced; or, in other words, for every 1,000 cu. ft. of air required for combustion 650 ft. must be supplied by the blowers.

In the case of "B" classification or "positive" air, from 45 to 70 per cent of all air required for combustion may be induced, or for every 1,000 cu. ft. required only 300 to 550 ft. need be supplied by the compressor.

The cost of air per gallon with a compressor at 15 pounds is the lowest consistent with good atomizing and combustion conditions and it is shown that the cost of power for compressing is 80 pounds is over four times as great. The cost per gallon with one and two pound turbine type machine will likely be found the most economical in practice in the great majority of cases.

As has been previously stated, air supplied by the machines under the "B" and "C" classification will atomize heavy oil where those in the "A" classification will not. The cost of compressing at .0012 cents per gallon for 8-ounce air would make a most excellent argument in favor of the mechanical system were it not for the fact that the selected oil required for good operation with this system would put a premium of at least 25 per cent on the oil cost in a normal fuel market, making the cost of the selected oil .05 cents per gallon when the heavy oils are available at .04 cents.

Operation of one and two pound turbine machines places a cost of .002 and .0025 cents respectively per gallon on the oil fuel, while the operation of 15 pound piston machine adds a cost of .0015 cents per gallon and the 80 pound piston machine .006 cents per gallon.

Conclusion.

Consideration of the subject matter and figures of this paper should clearly show that the proper method of burning oil is with air pressure under the "B" classification or under some conditions with 15 pound air under the "C" classification.

Steam Turbines and Electrical Drives for Vital Auxiliaries

Coordinate Use of Steam and Electrical Units Assures Continuity of Operation and Economical Heat Balances.

By LINN HELANDER*

CONTINUITY of service, such as is demanded of the vital auxiliaries in steel plants, can only be assured by the co-ordinate use of steam and electrical units. In view of the growing concentration of steel-mill electrical power-generating apparatus, complete disruption of electrical service must be considered an increasing likelihood. Where but a single source of power is available, therefore, simple electrification of such auxiliaries as those in the water-pumping plant and the power plant is a hazard which is not warranted by the consequent savings either in investment charges or operating charges. These charges are negligible with respect to the value of the service that the auxiliaries provide and they should not, therefore, be a determining consideration except as a basis for making a choice between equally reliable layouts. Neither should the effectiveness of the heat balance be permitted to lessen the reliability of these auxiliaries, though careful consideration will usually reveal an arrangement which assures continuity of operation and good economies without excessive investment charges.

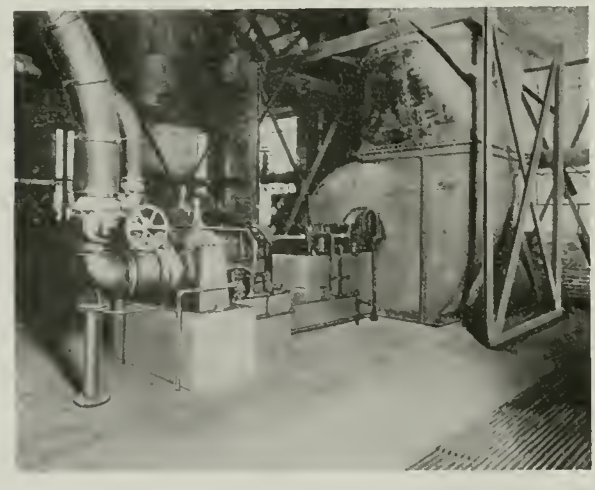

Fig. 1—Geared turbine unit driving induced fan. The gear, it will be noticed, is entirely enclosed so that dust, usually found in a boiler room, will not effect its operation.

Probably the most important part of a steel plant, judged from the necessity for continuous operation, is the main pumping station. Upon this station depends the continuous operation of all mills and furnaces, so that even a short interruption in its service will result in serious loss of production and very likely in disastrous accidents at the blast furnace. The value of the service of the main pumping station is, therefore, equal to that of the entire steel plant, and the value of its continuous service exceeds the value of the continuous service of the rest of the plant by the extent of damage likely to result from a sudden shutdown. Reliability in this case must be complete. The problem is not how much should be spent, but what is the best expenditure.

When steam is the only primary source of power in a steel plant generating its own power, reliability of service requires steam-driven apparatus, with or without the coincident use of electrically-driven apparatus. With this in mind, the main pumping station and the auxiliary pumps supplying the blast furnaces with water should be placed as closely as possible to the main boiler room. This probably will offer no considerable difficulty with regard to the auxiliary pumps. For the main pumping plant, however, it may require, if the ground be sufficiently level to warrant the expenditure, rather extensive tunneling. It is then the problem of the designing engineer to balance the fixed charges on the cost of tunneling against the fixed charges and operating costs of the steam piping and the electrical transmission lines. When a sufficient difference in level exists between the river and the boiler room, tunneling probably will be profitable only up to the point at which an abrupt rise occurs. Also, in this case it is likely that two pumping stations will be required; one at the river to pump the water to a sump at the level of the power plant, and another to take the water from this sump and pump it to the head tank and to the various parts of the mill. Reliability of service requires steam equipment in each of these pumping stations. The auxiliary pumps, however, may be located close to the boiler room, while the main pumping station will no doubt require rather extensive steam piping.

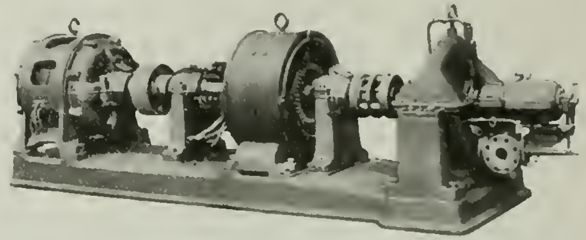

Fig. 2—Dual driven exciter—observe that the turbine is supported by pedestals at its center line. The simplicity of the arrangement, together with the availability of both steam and electric power, makes this unit essentially reliable.

Though steam-driven pumps are a prerequisite to reliability, increased reliability, sufficient to warrant the necessary investment, is obtained by using, in addition, electrical power. The use of both steam and electricity not only provides two means for the transmission of power to the pumping station, but also makes for flexibility in the layout of the pumping apparatus and permits distributing the service between electrically-driven and steam-driven units so that advantage may be taken of the economies that such distribution may effect. What the layout and distribution of loadings between steam and electrical apparatus should be depends upon the size of the pumping station, the heat balance and other conditions inherent to the particular plant under consideration. Considerations of various arrangements, however, will illustrate the possible advantage of combined electrical and steam-driven pumps and the problems that the designing engineers must solve.

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*General Engineer, Westinghouse Electric and Manufacturing Company.

The heat balance for a steel plant can no doubt be worked out by making use of the auxiliary pumping station, the boiler-room auxiliaries, and the power-plant auxiliaries. The main pumping station also should be considered in this connection if it is not exceedingly remote from the boiler room. It is likely, however, since there is a practical limit to the distance low pressure steam can be carried profitably for heating purposes, that this plant should, preferably, be kept independent of the heat-balance layout. If this is done the problems in connection with it are principally the determination of the number of pumping units to be installed and the kind of drives to be used.

The minimum number of pumps for reliable service is three: Preferably four or more, depending on the size of the plant, may be installed. If three pumps are installed, two of these may be motor driven and one steam driven, or two may be steam driven and one motor driven, or dual drives may be used. When either three or four pumps are installed, two of these should be sufficient under the most severe conditions to take care of the demands on the station. If analysis indicates that motor-driven units for usual service give better economies than those obtainable with steam-driven units, the problem remains as to whether the spare steam unit, or units, should be dual driven or straight steam driven, and whether they should be provided with condensers or should exhaust to the atmosphere.

When three units are installed, the spare unit will be called upon not only when the source of power for the normally operating units is disrupted, but when, due to breakdown or other necessary outages, one of these units is out of service. Upon the frequency of the outage will depend largely the economies desired of the spare unit. If this spare unit is arranged so that it may be driven by either a turbine or a motor, that is, if it has a dual drive, outage of a normally operating unit will not involve a change in the source of power. The economy of the drive operating on steam in this case would not necessarily be a consideration. The unit rarely would be called upon for service and the prime consideration would be rugged and simple construction to provide the maximum assurance of response to sudden demands for its service. It should not, therefore, be encumbered with condensers. The dual drive has the additional advantage of providing a double assurance that the driving end of a spare unit will not be out of service. Its construction is simple and its immediate response to changes in the source of power makes it a highly desirable unit for this service.

When the spare unit is driven only by a steam turbine the choice between condensing operation and non-condensing operation rests upon the cost of steam, and upon the frequency with which the unit will be called upon for its service. If condensers are provided, a small, but nevertheless, additional hazard is put upon the spare unit, so that a desirable arrangement in this case would be two motor-driven units and two steam-driven condensing units. This would seem a desirable arrangement for a large plant, though for a small plant it is likely that a straight non-condensing unit would be preferable. It should be kept fully in mind that when three units are installed and one is a spare, the capacity of any one unit must be amply sufficient to provide for all the vital needs of the steel plant.

As regards the auxiliary pumps, the boiler-room auxiliaries and the power-plant auxiliaries, these are so closely related to the heat-balance that they cannot be properly selected without previous knowledge of the amount of low-pressure heating steam required. This heating steam should be sufficient not only to provide for heating the feed water, but also for heating the buildings during the winter months.

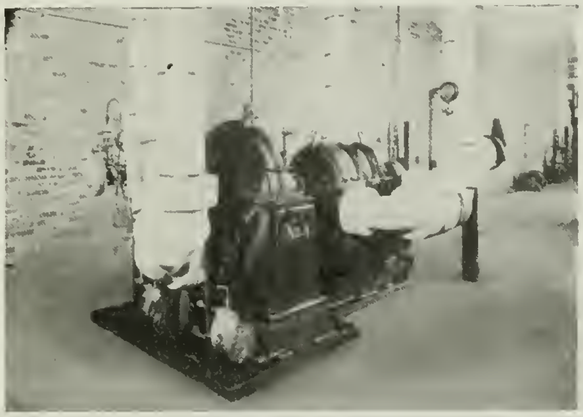

Fig. 3—The compact simplicity of a turbine-driven boiler feed pump, as compared with a reciprocating pump, is evident. Reliability of operation is further assured by supporting the turbine on pedestals at the center line. This permits free expansion of the casing without strain due to misalignment.

If a closed feed-water heater is used so that the pressure on the exhaust steam line may be maintained at 3 to 5 lbs., the building heating system profitably may be tied-in with the feed-water heating system. In this case, when all the auxiliaries are steam driven, waste exhaust steam should be avoided by returning any excess to the low-pressure blading of the main generating unit. A more satisfactory layout from the viewpoint of reliability, and one which has measurable advantages respecting heat balances, provides duplicate motor driven and steam units. This permits distributing the load between the steam and electrical drives so as to maintain at all times a desirable heat balance. Dual drives could profitably be used for this purpose as they provide a ready means for distributing the load between the steam and electrical drives with assured reliability.

When an open type of feed-water heater is used, the steam required for heating buildings should be obtained from a source independent of that supplying the feed-water heater. A convenient arrangement would be to provide the auxiliary pumping station with duplicate steam and electrically-driven apparatus. The steam-driven apparatus should be designed to operate against a back pressure of approximately 5 lbs. gauge and to deliver sufficient exhaust steam to supply the needs of the winter heating load. During summer months the motor drives should be operated. Dual drives also would have advantages in this connection.

As already intimated, the exciters, boiler feed pumps, and the units in the auxiliary pumping station should have both steam and electrical drives to assure against disruption of service. Forced-draft fans, induced-draft fans and condenser-circulating water pumps may be either steam or electrically driven. The choice will be based on the heat balance requirements and the economies obtainable by motorizing, taking into account probable losses due to disruption of the electrical source of power. Preference, however, should be given to an arrangement which provides both steam and electrical drives and, particularly in the boiler room, the straight steam drive should be looked upon as preferable to the straight electrical drive.

When waste-heat boilers are used on the open-hearth furnaces, the steam supplied by them probably will be sufficient to furnish the full needs of the gas producer and also leave additional steam for other uses. This steam should be used for developing power. To this end auxiliaries in the neighborhood of the waste-heat boiler should be provided with turbine drives. These preferably should have dual drives, and should be arranged so that during winter months the exhaust steam may be fed into the building heating system at the same time allowing for condensing operation during the summer months. The reduced load carried by the turbines during their winter-condensing operation would then be taken by the motors.

Parallel operation of steam-driven auxiliaries and motor-driven auxiliaries, together with the use of exhaust steam for feed-water heating, makes the use of centrifugal apparatus highly desirable. Centrifugal turbine-driven pumps provide a continuous non-pulsating flow of water which imposes no unusual conditions on the motor-driven pumps. Reciprocating steam-driven pumps, on the other hand, provide a pulsating flow of water. At each piston stroke the pressure in the discharge piping moves to a high and a low value. This variable head is carried to the motor-driven centrifugal pump and, inasmuch as centrifugal pumps are quite sensitive to changes in pressure, causes the flow from these to pulsate in unison with the reciprocating apparatus. This not only is undesirable from the viewpoint of maintenance but it also tends to lower the efficiency at which the system operates. Reciprocating pumps also discharge oil from the steam cylinders along with the exhaust steam and this oil, when carried to the boilers through the feed-water heating system, causes operating difficulties in connection with the generation of steam. Other advantages credited to the centrifugal pump as against the reciprocating pump, such as less floor space, smaller maintenance charges, flexibility, ease of regulation and greater efficiency, have been so largely demonstrated in practice, that modern feed-water pumping installations are practically invariably centrifugal pumps. A 300 g.p.m. reciprocating boiler-feed pump would require, for example, 65% more steam for the same service and 230% more floor space than a centrifugal pump.

Association of Iron and Steel Electrical Engineers Convention in Cleveland

The sixteenth annual convention of the Association of Iron and Steel Electrical Engineers will be held September 11 to 15 at Cleveland Public Hall, Cleveland, Ohio, at which there will be presented and discussed subjects dealing particularly with steel mill problems.

In addition to the meeting, an exhibition of electrical equipment will be shown in the Exhibition Hall. Here 65,000 sq. ft. of floor area will be used to exhibit the equipment of the various electrical companies.

The following program, which has been arranged by Mr. J. H. Kelly, Secretary of the Association, includes some particularly interesting papers, among which are the following:

"Improvement in Efficiency of Electric Power Supply," Dr. Charles P. Steinmetz, Chief Consulting Engineer, General Electric Company, Schenectady, N. Y.

"A Review of Steel Mill Electrification," B. G. Lamme, Chief Consulting Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., and Wilfred Sykes, Assistant to Operating Vice President, Steel & Tube Company of America, Chicago, Ill.

"Judging Combustion from Gas Analysis," A. G. Witting, Assistant Chief Engineer, Illinois Steel Company, Gary, Ind.

"Electrification of the International Nickel Company's Works for Monel Metal," F. C. Watson, Electric Superintendent, International Nickel Company, Huntington, W. Va.

"The Gas Engine as a Prime Mover for Power Generation," D. M. Petty, Electrical Superintendent, Lehigh Plant, Bethlehem Steel Company, South Bethlehem, Pa.

"Steam Turbines," L. W. Heller, General Superintendent Power Stations, Duquesne Light Company, Pittsburgh, Pa.

"Some Considerations in the Electrification of the Steel Plant Railroad Yard," R. B. Gerhardt, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.

"Power in the Iron and Steel Industry," D. B. Rushmore, Consulting Engineer, General Electric Co., Schenectady, N. Y.

"Boiler Practices of 1922"—Topical Discussion, J. B. Crane, Combustion Engineer, George T. Ladd Company; E. R. Fish, Vice President, Heine Boiler Company; R. M. Rush, Springfield Boiler Company; R. E. Butler, Babcock & Wilcox Company; F. Hodson, Electric Furnace Construction Company; Prof. Edgar Kidwell, Gen. Mgr., Kidwell Boiler & Engineering Co.

"Control Standardization," F. W. Cramer, Engineer of Tests, Cambria Steel Company, Johnstown, Pa.

"Motor Standardization," D. M. Petty, Electrical Superintendent, Lehigh Plant, Bethlehem Steel Company, South Bethlehem, Pa.

"Investigation of Insulators for Steel Mill Service," A. R. Leavitt, Engineer of Tests, Carnegie Steel Co., Duquesne, Pa.

"Electric Furnaces," E. T. Moore, Electrical Engineer, Halcomb Steel Company, Syracuse, N. Y.

"Lighting in Steel Plants," R. H. Bauer, Electrical Engineer, Carnegie Steel Co., Clairton, Pa.

"The Question of Safety in Steel Mills," F. A. Wiley, Electrical Superintendent, Wisconsin Steel Company, Chicago, Ill.

"Education," L. F. Galbraith, Electrical Superintendent, West Penn Steel Company, Brackenridge, Pa.

"Electrical Developments in 1922," R. B. Gerhardt, Electrical Superintendent, Bethlehem Steel Co., Sparrows Point, Md.

"Crane Standardization," R. S. Shoemaker, Superintendent of Maintenance, American Rolling Mills, Middletown, Ohio.

The Decomposition of Martensite into Troostite in Alloy Steels*

By HOWARD SCOTT†

ABSTRACT

The effect of the alloying elements, manganese, silicon, nickel, cobalt, tungsten, chromium, vanadium and molybdenum, on the decomposition of martensite to troostite was determined by means of heating curves. Only three of these elements showed a marked effect, namely, manganese, silicon and chromium. The first named increased the intensity of the transformation, while the last two raised its temperature when present in certain percentages. None of the alloying elements lowered the transformation and no general relation was found to exist between it and the higher critical point Ac_1*. The significance of these data in regard to the heat treatment and properties of alloy steels is discussed.*

THE significance of the critical point A_1 in steel and its relation to heat treatment is now fairly generally understood. There is, however, a transformation of nearly equal importance which occurs at lower temperatures on heating hardened steels and which is not widely recognized. It is intimately connected with the phenomenon of tempering, but has escaped the critical attention it deserves because the more common physical tests do not reveal it plainly. However, the development of thermal analysis apparatus which operates effectively in the low temperature range involved has made possible the convenient and accurate detection of the small heat effects associated with the transformation.[1] By means of this tool the essential characteristics of the phenomenon under discussion have been studied and their relation to the changes in certain physical properties of plain carbon steel on tempering pointed out.[2]

The evidence presented and reviewed in the above reference indicates that the transformation designated as Ac_t, which manifests itself as a heat evolution, marks the decomposition of martensite into troostite, a change of obvious importance in steel treating. This change which begins at about 170 deg. C., after slowly increasing in intensity reaches a maximum at 270 deg. C. and ends at 290 deg. C. for a normal rate of heating. However, on slower heating it occurs at lower temperatures consequently at a given temperature on the normal heating curve it has not progressed so far as if it were tempered a long time at that temperature, that is, as if heated at the hypothetical zero rate. For that condition the maximum is at 250 deg. C. and the end at 260 deg. C., which values are independent of the carbon content or quenching temperature.

It might be expected that alloying elements in steel will change the position of this transition and that some of the new properties conferred by the alloy may be due to that effect alone. Also there is the possibility that a knowledge of the characteristics of the change might aid in the interpretation of anomalies met with in the treatment of alloy steels. In recognition of these possibilities thermal curves were taken on the alloy steels available which represented eight of the principal alloying elements. The effect of rate of heating was not determined, but it is quite probable that it is very much the same as in carbon steels when the alloy does not change the transformation characteristics markedly.

Experimental Data.

The details of the experimental method used have already been noted in the papers mentioned so the tabulated data only are given here with a few representative curves, Fig. 1. In Table 1 are given the percentages of appreciably variable elements with the quenching temperature and medium used. The small size specimen used, about 2 grams in weight, prohibited the formation of troostite on quenching in oil as well as in water. The rate of heating is that just before the start of the transformation. The temperature of the three principal inflections in the curves are recorded under beginning, maximum and end when definitely discernible. The maximum is of course the most readily observed and important feature of the heat evolution. The intensity of the transformation has been indicated in the table by arbitrary values which are relative only. The last column gives the temperature of the maximum of Ac_1.

In order to compare the data for the alloy steels with those for carbon steels, the results from two carbon steels of 0.44 and 0.73 per cent C. content are given as these represent closely the carbon contents of most of the alloy steels used. From another viewpoint they represent also the class of structural steels and of tool steels respectively. Since all the commercial steels investigated contained both manganese and silicon, the effect of these two elements may properly be considered first. These elements have a decided though quite different effect on Ac_t. Manganese in the percentages employed increases the intensity of the heat evolution, but not the temperature appreciably. In fact the increased heat effect accounts for the

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†Associate Physicist, Bureau of Standards of the U. S. Department of Commerce.

[1] Scott & Freeman, B. S. Sci. Paper 348, A. I. M. E. Pyrometry Volume, p. 214, 1920.

[2] Scott & Movius, B. S. Sci. Paper 396, A. S. S. T., 1: 758 (1921).

TABLE I

Composition				Quenching Temperature °C	Quenching Medium	Rates of Heating °C/sec.	Ac_t (°C)			Intensity	Ac_1 Maximum °C
% C	% Mn	% Si	% Alloy				Beginning	Maximum	End		
CARBON STEELS											
0.44	0.36	0.06		900	water	0.12	174	270	286	3.0	731
0.73	0.29	0.01		900	"	0.12	175	271	292	7.0	731
PURE Fe-C-MN ALLOYS											
0.28	1.35			900	oil	0.12	174	269	288	1.3	725
0.44	1.00			900	"	0.13	174	276	297	6.0	727
0.90	1.61			800	"	0.13	...	276	307	12.0	718
0.90	1.61			800	"	0.11	169	277	307	16.0	727
SILICON STEELS											
0.70	0.41	1.98		900	water	0.12	...	454	473	2.5	...
0.70	0.41	1.98		1100	oil	0.16	...	458	475	2.5	767
0.41	0.86	3.00		900	"	0.16	...	481	498	2.0	790
NICKEL STEELS											
0.38	0.66	0.16	Ni 2.00	800	oil	0.12	186	281	296	1.5	706
0.38	0.66	0.16	Ni 2.00	800	"	0.12	171	281	300	2.5	707
COBALT STEELS											
0.62	0.34	0.43	Co 4.96	900	oil	0.15	...	277	305	2.0	766
TUNGSTEN STEELS											
0.70	0.29	0.27	W 0.95	900	water	0.14	173	287	304	3.0	736
0.67	0.38	0.26	W 5.10	930	oil	0.13	170	284	307	3.5	736
0.67	0.38	0.26	W 5.10	1200	"	0.12	173	304	326	3.0	746
1.18	0.31	0.38	W 5.20	900	"	0.13	166	288	316	6.5	...
CHROMIUM STEELS											
0.98	0.65	0.32	Cr 1.60	900	oil	0.14	180	295	320	10.0	755
0.72	0.49	0.19	Cr 2.18	900	"	0.14	164	304	329	11.5	753
0.75	0.49	0.19	Cr 2.18	1100	"	0.15	171	305	351	5.0	760
0.71	0.34	0.37	Cr 4.88	900	"	0.14	...	660	694	0.8	787
0.53	0.70	0.44	Cr 6.59	900	"	0.15	...	645	674	0.5	805
1.14	0.32	0.25	Cr 15.0	900	"	0.15	...	596	627	0.5	816
1.14	0.32	0.25	Cr 15.0	1100	"	0.13	541	621	648	5.0	815
0.46	0.67	0.13	Cr 12.2	900	"	0.16	...	580	621	0.8	807
0.26	0.85	0.70	Cr 13.2	900	"	0.15	...	593	611	1.3	871
0.26	0.85	0.70	Cr 13.2	1100	"	0.16	415	607	624	2.5	879
VANADIUM STEEL											
0.79	0.23	0.28	Va 0.26	900	oil	0.13	176	280	306	6.5	743
MOLYBDENUM STEEL											
0.71	0.28	0.28	Mo 5.75	900	oil	0.14	174	289	312	4.0	737
CHROME NICKEL STEEL											
0.40	0.31	...	(Cr 1.00 (Ni 2.78	900	oil	0.15	184	294	317	4.5	721
CHROME TUNGSTEN STEEL											
0.41	0.24	...	(Cr 1.50 (W 1.58	900	oil	0.15	175	299	335	1.0	773
MANGANESE-VANADIUM STEEL											
0.78	1.74	0.47	Va 0.22	800	oil	0.10	177	303	332	17.0	729

slightly raised maximum and end. Silicon, on the other hand, reduces the intensity, but raises the maximum about 200 deg. C. for a silicon content of 2 or 3 per cent. Ac_1, however, is lowered by manganese and raised by silicon. Evidently it is essential that these elements be kept fairly constant in determining the influence of other alloy constituents.

Two per cent nickel and five per cent cobalt do not affect the maximum of Ac_t in a marked way. It is raised 5 to 10 deg. C. and the intensity is perhaps slightly reduced although Ac_1 is strongly lowered by nickel and raised by cobalt. Tungsten acts in the same manner on Ac_t and there is little difference between the result for 1 per cent or 5 per cent. Ac_1 is only slightly changed.

Chromium steels were studied in a little more detail than the others, seven compositions being run. These show a very significant phenomenon best brought out by plotting the data as in Fig. 2. With increasing chromium content (up to at least 2.2 per cent), Ac_t rises slowly. In the gap between 2.2 and 4.9 per cent chromium it rises abruptly, about 360 deg. C., after which it falls slightly with further increase in chromium content. The exact limits of composition between which it changes from the low to the high temperature range can not be settled because of the limitations in compositions available. It is, however, evident from similar data furnished by Edwards & Norbury[3] that the upper limit is below 3.9 per cent chromium. This result is particularly surprising since there is no corresponding break in the curve for Ac_1. It is quite possible that silicon shows a similar phenomenon, but a sufficient variety of silicon steels was not at hand to test this point.

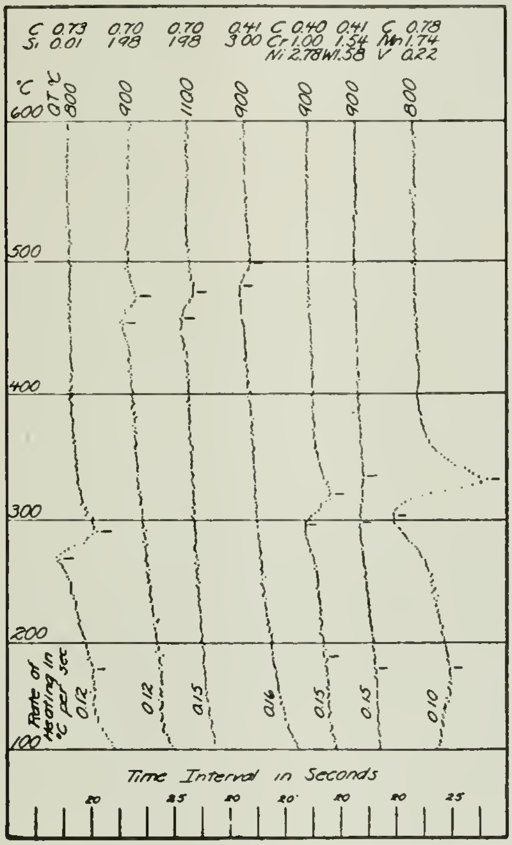

Fig. 1—Heating curves of some hardened alloy steels.

The vanadium steel and the molybdenum steel showed no markedly different characteristics from plain carbon steels except that both Ac_t and Ac_1 were raised somewhat. Combinations of two alloying elements in the three quaternary steels investigated chrome-nickel, chrome-tungsten and manganese-vanadium, acted as would be anticipated from the behavior of the individual elements.

Discussion of the Results.

There are a few general statements which might be made regarding the effect of the eight alloying elements considered. First, Ac_t substantially also raised Ac_1, but the converse is not true. The lack of a more general relationship is striking and evidence that an entirely different factor controls the precipitation of carbide at Ac_t from that at Ar_1.

Of the eight important alloying elements only three have a drastic effect on the heat evolution such as would be expected to be reflected in the technique of tempering. These are manganese, which increases the intensity, and silicon and chromium, which in certain percentages raise decidedly the temperature of Ac_t. It is therefore evident that the special properties conferred by the other elements are not due to variations in this transformation.

These facts suggest several observations regarding the tempering of alloy steels. If both manganese and carbon are high, as in some tool steels, and it is desired to temper well up in the Ac_t range, the steel should be heated very slowly to the temperature chosen, otherwise the large quantity of heat evolved may cause the temperature of the specimen to rise above that of the heating medium and so complete Ac_t. In this event the actual tempering would be higher than that indicated by the temperature aimed at. This is a highly undesirable possibility for the change in physical properties on passing from martensite to troostite is probably more pronounced than it is usually thought to be. It has evaded notice because of the lack of knowledge of the temperature range in which to look for it.

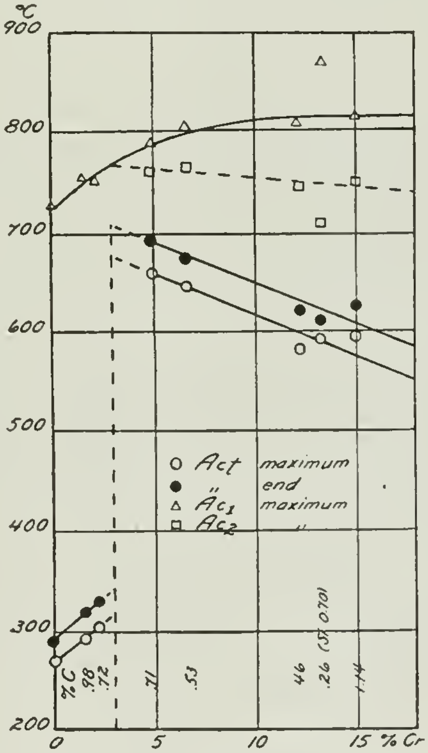

Fig. 2—Effect of chromium on the temperature of Ac_t, Ac_1 and Ac_2 in hardened chromium steels.

The steels with a high Ac_t have the interval between the end of Ac_t and beginning of Ac_1 shortened so that the troostite-sorbite tempering range is correspondingly reduced. The slope of the hardness-tempering temperature curve is thereby increased as shown by the curve for the silicon steel in Fig. 3. If commercial tempering is done in this range, the tempering temperature limits must be closer than in a steel of low Ac_t, in order to keep the hardness variations within the same limits. It is also evident from Fig. 3 that the other steels of this figure which have a low Ac_t soften at a lower temperature than does the silicon steel, but all of them have higher hardness when tempered to sorbite than the 0.70 per cent steel.

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[3] Edwards & Norbury; J. Iron & Steel Inst., 101; 447, (1920).

It has often been implied that the property of "red-hardness" in high-speed steel results from the ability of tungsten which is evidently a factor contributing to "red-hardness." If, however, the observation that Ac_t is not raised by 5 per cent tungsten also holds for higher contents, that can not be a valid explanation of the phenomenon. Referring to Honda and Murakami's magnetic curves,[4] which also reveal Ac_t, one finds that this change is raised only slightly by as much as 19.5 per cent tungsten, a degree quite insufficient to account for the resistance to tempering of high-speed steel. Evidently this characteristic property of high-speed steel is not conferred by tungsten, but by chromium, and the explanation of the function of tungsten must be sought along other lines.

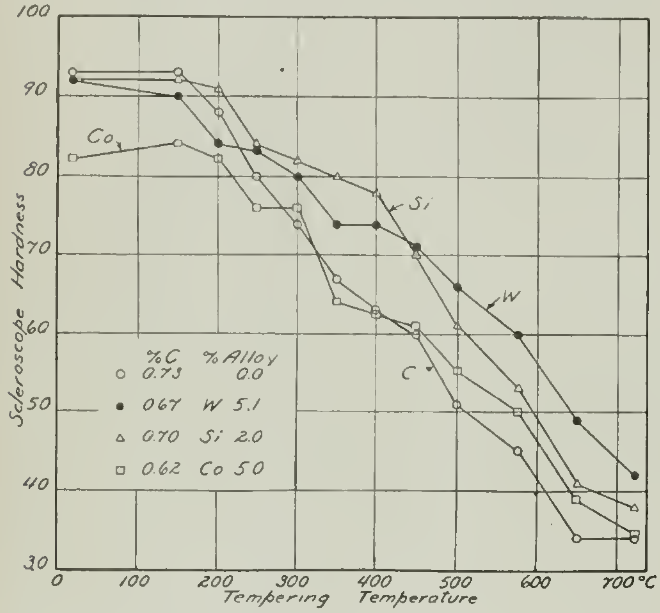

Fig. 3—Effect of tempering on the scleroscope hardness of carbon, tungsten, silicon and cobalt steels.

Thermal analysis, it is seen, offers a convenient method for determining the boundary between martensite and troostite of tempering which is a transition of considerable importance in the treatment of tool steel. It does not, however, give any indication of the change from troostite to sorbite which is of principal interest in the tempering of structural steels. A knowledge of the effect of alloys on this change is essential to a comprehensive analysis of the phenomena of tempering in alloy steels. The magnetic properties present a likely means for determining it accurately, but as yet few data are available. The comparison of alloy steels on the fundamental basis of constitution is dependent on such information.

Summary.

To summarize, it may be stated of the eight alloying elements manganese, silicon, nickel, cobalt, tungsten, chromium, vanadium and molybdenum, whose effect on the decomposition of martensite was studied by means of thermal analysis that only three, manganese, silicon and chromium, change the characteristics of the transition substantially. Of these, the last two raise the temperature of the transformation to a degree which may affect the tempering given to secure a predetermined constitution. In no case is Ac_t lowered. The two elements which raise Ac_t also raise Ac_1, but the latter not as much as the former, thereby shortening the troostite-sorbite tempering range. However, all elements which raise Ac_1 do not raise Ac_t. Hardness-tempering temperature curves show the effect of silicon in maintaining hardness for higher tempering temperatures than in carbon steel and that of tungsten, cobalt and silicon in increasing the hardness of highly tempered steel. It is shown that chromium and not tungsten is the element in high-speed steel which develops resistance to tempering.

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[4] Honda and Murakami: Sci. Reports Tohoku Imp. Univ., 6, 235, (1918).

ETCHING REAGENTS FOR ALLOY STEELS

Several series of "sequence etchings" have been tried out by the U. S. Bureau of Standards on a specimen of high-speed steel which was in the "as received from the mill" condition. Sequence etching means the etching with two or three reagents in successive order without any repolishing of the section between the etchings, and the taking of photomicrographs after each etching at the same spot in the microsection in order to note any changes in microstructure produced by the last etching as compared with that developed by the preceding etching reagent.

The reagents used in various combinations were: (1) Dilute ammonium hydroxide solution, together with a weak electric current, the specimen being made positive pole; (2) two per cent alcoholic solution of nitric acid; (3) boiling sodium picrate; and (4) Murakami's reagent (solution of potassium ferricyanide and sodium hydroxide) at boiling temperature.

The results, as judged from the behavior toward the various etching reagents tried, appear to show that there are at least three different constituents present among the imbedded globules or particles in the specimen of high-speed steel, in the "as received from the mill" condition, though any attempt to state the nature of these constituents would, in view of present developments, involve speculation.

DRILL STEEL SURVEY REPORT

The first progress report to members of the advisory board to the Bureau of Mines and the Bureau of Standards on the breakage and heat treatment of rock drill steels and other steels and alloys subjected to similar impact stresses has been made by Dr. H. Foster Bain, director Bureau of Mines, and Dr. S. W. Stratton, director Bureau of Standards, covering the work done in the month of April.

The survey was begun on April 1 with the object of determining the present status of the types and sizes of drills as related to the heat treatment and breakage of rock drill steels. During that month a large number of mines, largely copper, were visited by F. B. Foley and H. S. Burnholz, metallurgists Bureau of Standards. The report, which is a lengthy one, gives the practice of each mine as to the kind of bit, the size of steel and in some cases the heat treatment used. No conclusions are drawn or comments made.

Breakage of Rolls on Sheet and Tin Mills

General Discussion Giving the Cause For Rough Rolls On the Mills and the General Effect That They Have Upon the Product.

By W. H. MELANEY

PART III

ONE of the most annoying as well as costly conditions on Sheet or Tin Mills, is the roughing up of the chilled surface of the rolls during the rolling process. Especially is this true when making high grade sheets such as are used in the manufacture of automobiles, where an almost perfect surface on the sheet is required.

This roughing up can be divided into four classes, each one of which has its individual characteristics and is totally different from either of the other classes.

The first is the most prevalent one, the one that gives the most trouble and is known as gathering. The second is known as pitting. The third as simple roughness and the fourth as crazing or checking, because of the fine raised check lines in the form of squares left on the surface of the sheet.

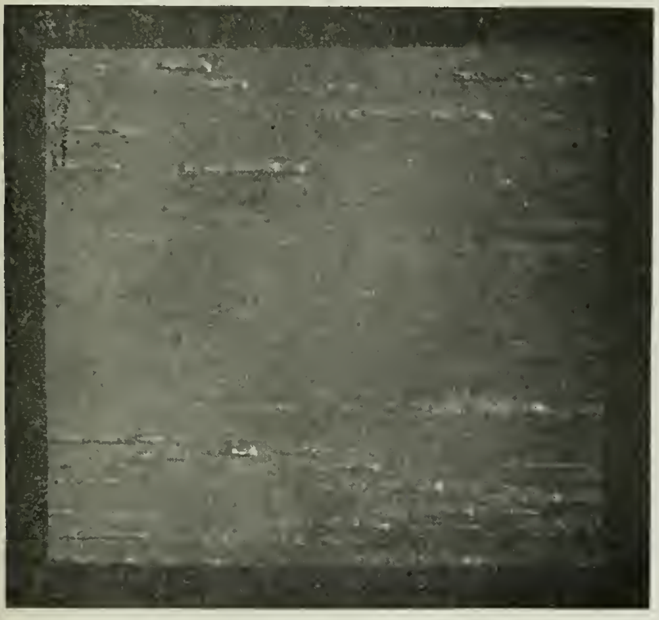

Fig. 1—Part of sheet showing the effects of gathering.

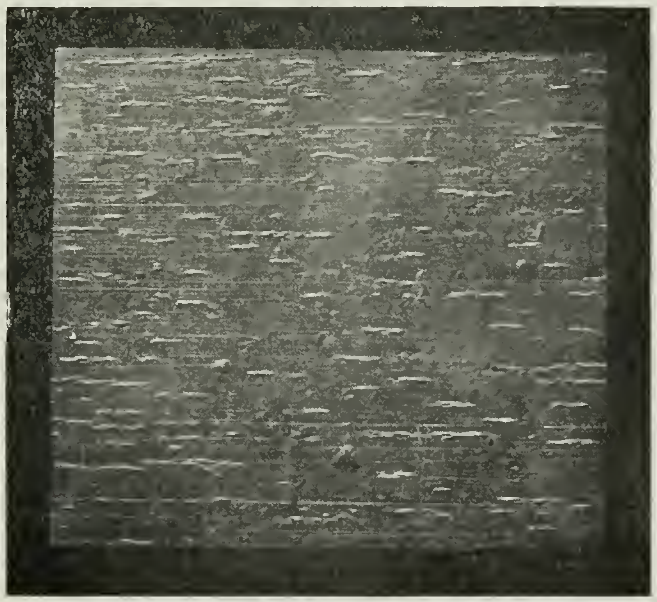

Fig. 2—Part of sheet showing the effect of pitting.

The roughing up of the surface of the rolls is most troublesome in the beginning of the week, because of the unfavorable conditions under which the rolls are then operating and will be discussed later on under the proper heading. Roughing up is not to be confused with bad surface on the sheets, due to scale or other impurities in the sheet bar, being rolled into the face of the sheet, nor with any imperfections caused by deposits of ash or other products of combustion left on the sheets by the furnaces.

In dealing with roughness, the first thing to be considered is to which class it belongs, as the remedy will be different in each case.

Gathering.

Gathering is that form of roughness where the face of the roll becomes covered in certain well defined bands, by small particles of extremely hard substance, evidently steel built up on the face of the rolls, standing out in relief and which due to the pressure and the revolving of the rolls, are finally elongated or stretched into streaks or lines in the direction of the rolls.

These lines being in relief cut into the face of the sheet and produce indentations that are impossible to remove by any amount of cold rolling and in the case of very thin sheets, cut completely through the surface sheets of the pack. This is why this form of roughness is the most objectionable, as the effect once produced on the sheet it is impossible to remove it by any future treatment. See Fig. 1.

Cause of Gathering.

There are a number of causes for gathering, several of which may exist at the same time.

An extremely mild chill roll is more susceptible to gathering than a harder one, because the more open the structure of the metal composing the face of the roll, the more readily the small particles will build up on its face. The primary cause of gathering, however, is one of friction and can be produced in various ways.

When two sheet or tin rolls run together after being heated up, as the top roll is driven by friction from the bottom roll, there will always be some slight slippage or lagging of the top roll, due to difference in neck lubrication, or the rolls being slightly crossed, that is, out of perfect alignment with each other, or perhaps too tight lining up of the side brasses or not enough end play, thus causing a variation in the friction load of the top roll. This results in friction between the surfaces of top and bottom rolls, because the rolls are hot and of course unlubricated and small particles of metal are torn out of the face of the rolls, where the two surfaces touch, and also out of the surface of the pack or sheet bar.

These particles, due to the pressure of the top roll upon the bottom one, adhere to one or both rolls and gradually build up under pressure and elongate in the direction of the rotation of the rolls until these gathered particles form a pronounced ridge or projection upon the face of the roll, which requires frequent scouring with a carborundum block to remove.

This, as will be noticed, forms most readily on that portion of the roll's face where narrow bearings occur, as the roughness of these bearings offer more favorable conditions for the building up of these small particles of steel and when they appear, they must be removed by scouring the surface of the roll with a coarse carborundum block, which cuts away these projections and leaves the surface of the rolls smooth again.

The purer the steel in the bar or pack, that is being rolled, that is the lower the sulphur and phosphorus content, the more the trouble that will be experienced from gathering. This is due to the fact that the small particles of steel torn out of the face of the bar, will weld up under pressure, much more readily when pure than when the phosphorus and sulphur content is higher.

Also, bars heated with gas give more trouble from gathering than those heated with coal, because the sulphur in the coal produces a sulphur oxide on the face of the bar, which being only skin deep, does not effect the interior of the bar, therefore, is not deleterious to the quality of the sheets and is not objectionable.

For the same reason, pickled bars give more trouble from gathering because all the scale has been removed, leaving pure particles of steel to be torn from the pack which weld up readily under the pressure of the screws of the mill. This is the reason that gathering is more apparent when too much screw is used on bar or packs, as the greater screw pressure produces a better welding condition.

Gathering occurs most in the fore part of the week, because the condition of the face of the rolls at this time is most favorable to gathering.

This is caused by the turning or dressing of the rolls in the roll lathe, as the dressing off of the rolling face of a chilled roll is decidedly a scraping rather than a cutting process and this opens up the grain of the chill and leaves an open texture that the small particles of steel readily adhere to.

After the rolls have been run long enough to close up their face, due to the pressure of the two rolling surfaces upon each other, gathering is not so apt to appear as the hardened surface will not permit the particles of steel to adhere.

Pitting of Rolls

The pitting of rolls is a different type of roughness and results from several causes, but is not as serious as gathering, because in this case the pitting, as the name implies, leaves small depressions in the face of the roll, which in turn leave projections on the sheet which are easily removed by the cold rolls. See Fig. 2.

The worst form of pitting is caused primarily by the gathering being permitted to remain on the race of the roll too long before it is scoured off. The result is the elongated ridges built up on the face of the roll and which are harder than the roll face and due to the pressure of the rolls upon each other, these ridges are sunk partly into the face of the roll and when the ridges are scoured off they leave underneath these ridges, a depression in the face of the roll, corresponding in size and shape, to the ridges that produced them, so that the sheet looks much the same as it did under gathering except that instead of leaving indentations in the face of the pack, which would ruin it, they are now small projections similar in shape and size, to the original ridges that produced them, and which can be rolled down on the cold rolls but do not make a perfect finish on the sheet.

Another form of pitting is due to small particles of scale torn from the bars and packs being rolled into the face of the rolls, forming small irregular indentations which leave projections on the face of the pack. They, of course, are removed by the cold rolls and while not desirable, are not so serious as other forms of roughness and can be more readily removed by the scouring block.

Rough Surface.

This type of roughness usually appears in streaks or bands around the circumference of the rolls and is caused by narrow bearings where the surfaces of the top and bottom rolls come in contact with each other, and the slippage of one roll upon the other roughens up the surface very rapidly after the rolls become heated and this would happen, even though no metal was being rolled.

This type of roughness results generally, either from uneven expansion of the rolls, or uneven polishing, and under this condition, is more or less under control of the roller, but it can also be caused by careless roll turning and when this is true, the only solution is to re-dress the rolls.

Another condition that sometimes happens when newly dressed rolls are put into service, is polished streaks on the surface of the sheets and is caused by exactly the same conditions as noted above, that is, the rolls only touch in streaks and this closes up the grain of the chilled surface on these narrow bearings, which had been opened up by dressing.

The surface of the roll at these places becomes denser, due to compression, and leaves a polished streak upon the sheet, but if allowed to continue without acouring off, they will eventually develop into rough streaks.

Crazing of Rolls.

Crazing of rolls is not a very serious condition usually, as its effect on the sheets can be removed by the cold rolls.

By crazing is meant the finely checked or grained surface of the roll, leaving a fine hair line in relief all over the surface of the sheet, crossed at right angles by other hair lines forming fine squares or checks all over the surface. If you examine the rolling surface of the rolls closely, you will find it all broken up into squares (giving it a grain-like effect) by fine cracks no larger than a hair. These leave the lines in relief on the sheets and can be removed by the cold rolls with no apparent bad effect except when the squares are so large as to be plainly noticeable on high grade surfaces, such as automobile sheets, and this sometimes happens.

This crazing is caused by the rapid expansion of the chilled surface of the rolls, both longitudally and circumferentially, really tearing the skin of the surface apart and the slower the rolls are warmed up the finer will be the checks and when the squares become large enough to be objectionable, it is an indication that the rolls were too rapidly brought up to working temperature and the roll in expanding started to tear its surface apart as chill, like glass, is of a crystalline structure and very sensitive to heat conditions. It is obvious that the way to avoid this condition is slower warming up.

You will also note that when the rolls are gagged or in any other way stopped with a hot bar or pack between them, that these squares on the surface of the roll at the point of contact with the hot bar are very much enlarged, due to the rapid heating of the surface of the roll and when this happens, a condition is started in the roll that will ultimately cause it to break, as it is already badly ruptured on its surface and these cracks extend practically through the chill.

Spawls

This is also one of the causes for rolls spawling, although the spawl does not usually occur until later on and this is the reason the statement is so often made, that the roll spawled without apparent cause as the cause may have happened long enough ago to be overlooked.

Another cause for spawls, of course, is a crush, due to rolling a pair of tongs or a cold black end, and as stated above, does not occur until later on, when the cause has been forgotten.

This is the reason a roll manufacturer will not replace a spawled roll, as it is purely a mill condition and not an inherent defect in the roll itself.

Combustibility of Blast Furnace Fuels

The Influence of Structure On the Combustibility and Other Properties of Solid Fuels Used In Steel Works.

By E. R. SUTCLIFFE and EDGAR C. EVANS

THE influence of structure on the combustibility of fuels is a subject which has received very little attention. The most systematic work on the subject has been in connection with fuels for blast furnace purposes, chiefly between 1884 and 1890, and this work still retains a considerable interest.

Thörner made a most interesting investigation in 1885 on the structure of blast furnace steels (Stahl und Eisen, 1886, 6, 71). His memoir was accompanied by some very instructive photomicrographs of sections of coke and charcoal. He found that the fuels which gave the best results in the blast furnace, viz., Meiler coke and charcoal, were characterized by high combustibility, high degree of porosity, and comparatively high percentage of volatile matter, and that they contained pores, the cell walls of which were either longitudinal in direction or had a pronounced tendency in that direction. He quotes his results as being in agreement with those of Belani and Kutscher, who from practical experience had come to the conclusion that the ideal furnace coke should be "as voluminous, as rich in pores, and as similar to charcoal as possible."

Later Belani (Stahl und Eisen, 1885, 5, 603) suggested that the heating value of a fuel per unit of time depended on the combustibility of the fuel and on the amount of surface presented to the draught. He found that the (surface of charcoal): (surface of coke) = 5.5:1 and the (combustibility of charcoal): (combustibility of coke = 1.5:1, from which he calculated that the ratio of the heating power of charcoal per unit of time to the heating power of coke per unit of time is 5.5 × 1.5 = 8.25:1.

Very little work has been done in England on the influence of structure on the properties of fuels, probably because of the fact that the use of charcoal in metallurgical operations had been discontinued in England long before blast furnace technology had reached the level of an exact science.

Even Bell, in his monumental work on the blast furnace, had to depend for his knowledge of charcoal as a fuel, almost entirely upon the evidence submitted from abroad, and the question of "combustibility" as apart from "heating value" plays therefore very little part in his calculations.

Armstrong, however, in his paper on the "Mechanics of Fire" (J., 1905, 473), pointed out in a footnote the important possibilities of changes which constitute the process of combustion, while Bone's work on surface combustion emphasized in a remarkable way the importance of structure in the combustion of gases on an incandescent surface.

At present, while it is realized that structure does play a part and an important part in the combustion of coal and other solid fuels, the complexity of the combustion phenomena in the case of non-carbonized fuels has made it extremely difficult to determine the nature and extent of its influence, while in the case of carbonized fuels—particularly gas coke and furnace coke—the phenomena of combustion are also complicated by the refractory character of the graphitic skin of carbon which is formed during most processes of high temperature carbonization.

The possibilities of structure in the combustion of solid fuels were brought home to the authors in a rather interesting manner in connection with a mine fire in South Wales. The fire had been burning for several

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Abstract of paper read by authors before Society of Chemical Industry Burlington House, April 3, 1922.

months, and to prevent it spreading, the fire zone had been totally enclosed by brick stoppings, while further, very considerable quantities of carbon dioxide had been injected into this screen (vide Proc. Inst. Mn. Eng., V., 51, 209). By this means it had been found possible to reduce the oxygen percentage to 1.5—3.0 per cent, but even this small proportion proved sufficient to maintain slow combustion, and it was ultimately decided to quench out the fire. For this purpose one of the brick stoppings was removed. The effect of increasing the oxygen percentage on the burning coal was extremely interesting. When first viewed through the open stopping the face of the seam was black; the slow combustion that was taking place was not sufficient to raise the temperature to the ignition point, but as the increased percentage of oxygen began to exert its influence active combustion started. It did not, however, commence at one point, but started at a number of points entirely isolated and independent of one another, making the coal seam appear like a number of stars. Combustion did not spread from these, but the stars simply multiplied, breaking out one after another independently until finally the whole seam was covered, and appeared to be a red burning mass.

Even at that time the phenomena observed seemed apparenty to be due to surface combustion at points where conditions were favorable. The illustration is of some interest in view of recent work, and has a significant bearing on some of the views advanced later.

When the question of combustion of coal is studied in detail, the problem is very seriously complicated by the heterogeneous character of coal. A number of observers have studied the question of the ignition temperature of coal. Tables of ignition temperatures are frequently published which show a gradual increase on passing from bituminous coal to anthracite, but these tables after all simply give the temperature at which the gases evolved from the coal ignite, and these temperatures vary not only with the coal, but with the different constituents of coal itself.

The constitution of coal has been studied by a number of observers, and notably by Wheeler and his collaborators, and the essential difference between various coals can easily be realized by a study of photomicrographs of coal sections. But while these photographs show clearly the internal structure of coal, while they show the heterogeneous character of most coals, and explain the difference in ignition temperatures of various coals, they do not themselves explain the very considerable differences in combustibility. Some coals are said to be "bright" and "active" in combustion, others again of similar content of volatile matter are said by stokers to be "dead" in burning. The reason for this is not entirely due to composition or constitution; it is a matter in which the structure of the carbonaceous residue left after the volatile products have been burned off plays an extremely important part.

In examining the question it is advisable at the outset to simplify the investigation by studying the behavior of coals which neither fuse nor decrepitate in the furnace. Highly fusible resinous coals which cake together in a grate or in a boiler furnace form a semi-caked mass which has to be poked and stirred frequently to allow of the free passage of air and heated gases through it.

Other coals decrepitate and fall to pieces, leaving a dust which impedes the action of the air blast, and to avoid complicating the field of study it is advisable to eliminate both these classes, and to select coals which burn easily and steadily without necessity for excessive poking. South Wales steam coals offer excellent possibilities in this direction, while high volatile non-caking coals can also be studied to advantage.

The combustibility of a fuel of this type may perhaps be defined as the ease with which it combines with oxygen. This involves the time factor. The rapidity with which a fuel burns may be taken as a criterion of its combustibility. It is not a question of calorific value. Two different fuels may have the same calorific value, but one may burn much more easily and much more quickly than the second, and the consumption per square foot of grate area per unit of time may be considerably greater. The temperature attained by combustion may also be higher. As an extreme example, the old textbook illustration of the rusting of iron may be quoted. The heat units produced might be the same as if it burned in oxygen, but the temperature attained is very different in the two cases.*

A method that has been used in determining the combustibility of a carbonized fuel is to note the effect of air and of carbon dioxide upon the fuel at various temperatures, and to note the loss of weight in successive periods of time (Thörner, *loc. cit.*, and Bell, "Principles"). By this means it has been found that the porosity of a fuel plays an extremely important part in determining its combustibility.

In studying on a large scale the factors that play a part in determining the combustibility of a fuel, the first step is to obtain a homogeneous product. At the outset it will be noticed that homogeneity itself, apart from other factors, exerts an important influence.

Homogeneity of Size.

The first attempts to obtain a homogeneous fuel commercially have been in the direction of sizing the coal. Sizing non-caking steam coals, anthracite coals, and some American high volatile coals (*e.g.*, Illinois coals) has proved of considerable advantage for steam raising purposes.

In so far as American anthracite is concerned, sizing has been absolutely necessary for the following reasons (Cullon, "Cours d'Exploitation des Mines Texte," III., 183). (1) Pennsylvania anthracite will not decrepitate in the fire to burn without sizing. (2) If in too large size the cold mass will be in too great proportion to the incandescent surface. (3) The sizes should be the same so that all particles should be under the action of flame at the same time. (4) Small particles should not be so numerous as to fill up the spaces between the large particles, and thus impede the passage of the air and heated gases.

In the case of non-caking bituminous coals, the following advantages are claimed for sizing (Malcolmson, First Annual Convention Int. Railway Fuel Assoc., 1909). (1) Increase of fuel and boiler efficiency. (2) Less loss of fuel in ash. (3) Less smoke. (4) Uniform combustion insuring greater capacity of furnace. (5) Less draught needed. (6) Longer life of grate. (7) Furnace under better control. Steam can be raised more rapidly. (8) Less danger of spontaneous combustion of stored coal.

The claim for increased furnace efficiency has not been confirmed in detailed tests made by the U. S. Bureau of Mines, but the other advantages are generally acknowledged, and the large market that exists for sized

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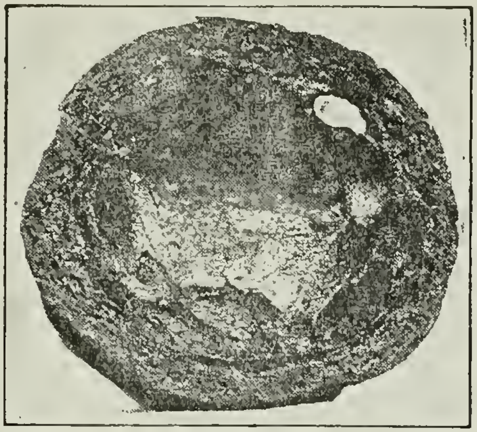
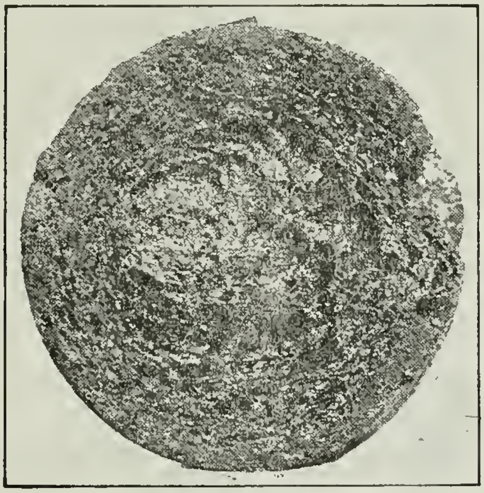
*This illustration is, of course, not strictly correct, as the oxides are different.



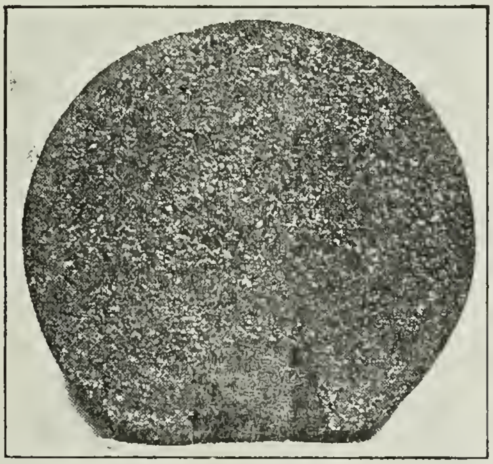
Low-temperature coke.—From No. 2 Rhondda coal. Natural size.

FIG. 1.



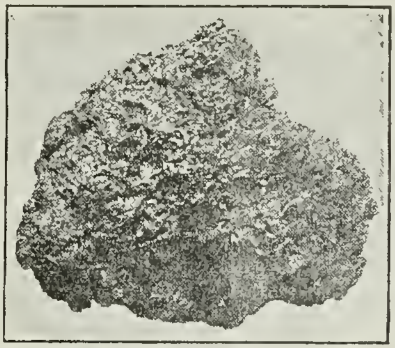
Low-temperature coke.—From No. 2 Rhondda coal, mixed with a proportion of coke breeze. Natural size.

FIG. 2.



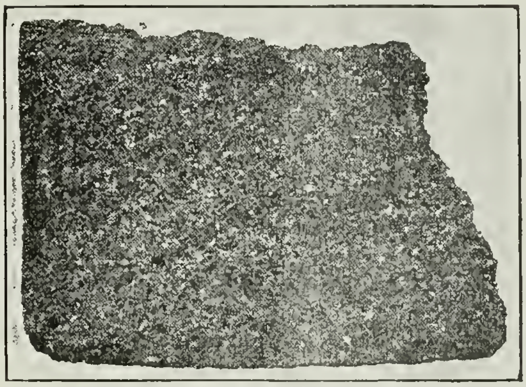
Low-temperature coke.—From No. 2 Rhondda coal, mixed with a proportion of preheated coal. Natural size.

FIG. 3.



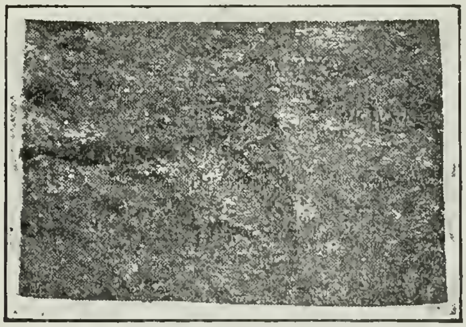
Coalite. Half natural size.

FIG. 4.



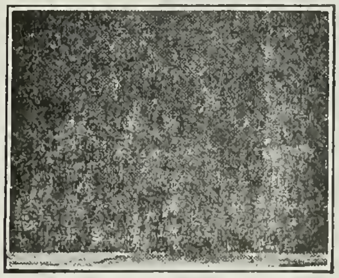
South Metropolitan smokeless fuel. Natural size

FIG. 5.



Pure coal briquette—Carbonised—South Wales steam coal. (No addition of coke.) Natural size.

FIG. 6.



Pure coal briquette—Carbonised—(Lancashire coal mixed with 25% coke breeze.) Natural size.

FIG. 7.

coal proves that it has many important advantages in large-scale work.

Influence of Dimensions of Fuel Particles.

Ceteris paribus, the smaller the particles of coal, the greater the combustibility. This, of course, arises from the fact that the surface area increases considerably in proportion to the bulk as the diameter decreases. This principle is applied in using anthracite for raising steam.

Anthracite is by no means a fuel of high combustibilty, and is extremely difficult to burn in an ordinary boiler furnace if in large sizes. Yet anthracite peas carefully sized make an ideal boiler fuel and have better steam-raising qualites than even high-class Welsh steam coals.

The ultimate possibilities in this direction are obtained in the case of powdered fuel. The extremely high degree of combustibility of coal dust in a fine state of subdivision has long been realized in connection with the study of mine explosions, and the same principles which make coal dust such an explosive agent, are now made use of commercially in many applications of powdered fuel.

Powdered fuel, however, is by no means an ideal material. It cannot be stored, it cannot be transported *per se,* and is liable to spontaneous combustion. For this reason attempts have been made, as in the colloidal fuel process, to make it transportable in the form of an emulsion of oil and coal. There is, however, a method of retaining to some extent the highly combustible extremely active properties of powdered fuel, and at the same time make it easily transportable, and that is to briquette it.

Homogeneity of Size and Structure.

It is perhaps an euphemism to regard patent fuel briquettes, as customarily made, as consisting of powdered coal.

The advantages of fine grinding prior to briquetting have long been known to the briquetting industry. It increases the combustibility of the briquettes, and improves their appearance, but on the other hand finely ground coals require a greater percentage of binder than coarsely ground material, and as a rule, if made by the ordinary process with pitch as a binder, the briquettes are rather weaker. In practice, therefore, a compromise is effected, and the coal is only ground to the extent that would be effected by an ordinary Carr's disintegrator. Even so, briquettes made with pitch possess many advantages over coal, and these have been summarized as follows (*vide* Malcolmson, "Commercial Aspects of the Coal Briquetting Industry," Trans. 8th Int. Cong. Appl. Chem., Vol. 25). (1) Briquettes can be readily transported and handled and stored for an indefinite period without deterioration. (2) Briquettes when burned in locomotives under standard conditions show an increased boiler efficiency over coal of the same calorific value amounting to 15 per cent in favor of the briquettes. (3) It has been demonstrated that 25 per cent more briquettes than coal can be burned per sq. ft. of grate area per hour.

In other words, briquettes are more combustible than raw coal, a result entirely due to the difference in structure between briquettes and coal.

The principal advantages of briquettes can ultimately be attributed to their homogeneity both in respect to structure and to the size of the particles of which they are constituted.

Briquettes made with pitch in the usual way are not entirely homogeneous. The coarsely ground coal of which they are made is not uniform in size and the addition of pitch introduces a further complication.

A stage further in the direction of homogeneity can, however, be attained by making briquettes without the addition of binding material, the briquettes thus consisting of uniformly sized particles of the raw coal itself cemented together by the binding material in the coal substance. Briquettes of this type can be obtained by finely grinding the coal and subjecting it under suitable conditions to a pressure of about 10 tons per sq. in. For all practical purposes briquettes of this type can be regarded as solidified coal dust; they are considerably more homogeneous in structure and constitution than any of the fuels yet dealt with, and a study of their properties serves to illustrate in many ways the effect of structure on the general properties of fuels.

The combustion of these briquettes in a domestic grate proceeds with much greater regularity and uniformity than that of raw coal and presents the following special features: (1) After the volatile matter has been burned away the briquettes burn easily and steadily in a similar manner to charcoal. (2) They remain ignited until practically the whole of the carbonaceous matter has burned away, leaving no clinker, but only a residue of finely divided ash. (3) The radiant heat emitted from a fire of these briquettes is considerably greater than that from a coal fire.

The following comparative test made with a raw coal of volatile matter 35 per cent, ash 5.6 per cent, and briquettes from the same coal made without a binder may serve to illustrate the difference between the combustion of briquettes and raw coal:

	House coal	Briquettes
Weight taken	6 lbs.	6 lbs.
Time taken in burning	6¾ hrs.	9½ hrs.
Unburned cinders	20½ oz.	1 oz.

The unburned cinders from the briquettes were found in the extreme corners of the grate. The material in the center had burned completely away.

The proportion of unburned cinders left in both cases is significant. A coal fire goes out because the heat generated at the incandescent surface becomes too low to raise the temperature of the cold mass to the point of ignition. If, however, the area of the incandescent surface is increased, or alternatively, if the temperature of the unburned mass becomes raised during the combustion process, combustion will proceed.

Despite the fact therefore that the period of burning of the briquettes was longer than that of the coal, their combustibility was considerably greater.

The fact is brought out by a series of comparative boiler trials made at the South Wales School of Mines on raw coal, briquettes made from the same coal with pitch as a binder, and briquettes from the same coal made without a binder. In a series of preliminary laboratory tests it was noticed that briquettes made without a binder when burned in a bomb calorimeter burned with a rapidity far greater than that of either raw coal or briquettes made with pitch, the period of combustion being very often 30 per cent less than that of coal. This increased combustibility is shown with still greater clearness in the series of tests summarized in Table I.

These tests are imperfect in several respects; the boiler efficiency was low (as would naturally be expected in the case of hand-fired experimental boiler installation) and in many respects they failed to bring out to the best advantage the superiority of the briquetted fuels. Still the following points may be noted:

1. The heat transmitted per sq. ft. of heating surface per hour was 4070, 4039, and 4650 Btu. respectively.
2. The weights of dried fuel burned per sq. ft. of grate area per hour were 13.78, 15.05 and 16.4 lbs., respectively.
3. The equivalent evaporations per lb. of carbon value from and at 212 deg. F. were 7.31, 7.31 and 7.35 lbs., respectively.

4. A constant draught of 0.6 in. was maintained in each case, and a uniform rate of feeding the coal was adopted in each case. The briquettes made without a binder, however, burned away so quickly that with the thin fires maintained it was found very difficult to keep the grate fully covered at the end of the charging period. The efficiency therefore was reduced, and a better result could have been obtained either by reducing the draught or by working the boiler at a higher capacity.

Table I—Summary of comparative tests made at the South Wales School of Mines.

Fuel	Raw coal Pct.	Briquettes made with pitch Pct.	Pure coal briquettes Pct.
Ultimate analysis			
Carbon	86.3	82.3	82.1
Hydrogen	4.3	4.0	4.1
Ash	4.2	8.30	7.71
Sulphur	0.95	0.98	1.15
Oxygen Nitrogen	4.2	4.42	4.94
Moisture in coal	0.77	1.6	0.85
Analysis of boiler ash			
Moisture	2.37	0.23	0.85
Ash	51.80	63.25	34.25
Carbonaceous matter	45.83	36.52	64.9
Flue gas analysis			
Carbon dioxide	5.04	5.2	5.9
Carbon monoxide	nil	nil	nil
Oxygen	15.00	15.00	14.5
Nitrogen	79.96	79.80	79.6
Heat transferred to water per lb. of dried coal, Btu	7426	6550.4	6997
Lower value.			
Calorific value of dried coal, Btu.	14,781	14,182	13,937
Heat transmitted per sq. ft. of heating surface per hour	4070	4039	4650
Weight of dried fuel fired per sq. ft. of grate area per hour, lb.	13.78	15.05	16.3
Equivalent evaporation of water from and at 212 deg. F. per lb. of dried fuel, lb.	7.52	6.85	7.25
Weight of feed from and at 212 deg. F. per sq. ft. of heating surface per hour, lb.	4.225	4.225	4.81
Equivalent evaporation per lb. of carbon value of fuel, from and at 212 deg. F., lb.	7.31	7.31	7.55

The results, however, are sufficient to show that the combustibility of briquetted fuel increased with the degree of fineness of the coal and with the homogeneity of the product.

The Combustibility of Natural Fuels—Summary.

In so far as natural fuels are concerned, the conclusions derived from the preceding notes may be summarized as follows:

1. Uniformity of size allows of an increased quantity of fuel being burned per unit of time per sq. ft. of grate area.

2. Briquettes burn at a faster rate than coal under equivalent conditions.

3. Fine grinding of coal for briquetting purposes increases the combustibility of the resulting product.

4. Briquettes made without a binder are more combustible than those made with a binder.

It seems evident from a consideration of the properties of briquetted fuel that structure plays an important part in determining their combustibility. The secondary reactions resulting from the presence of volatile matter make it difficult, however, to determine the nature and extent of its influence, and definite conclusions on the subject can only be come to after an examination of fuels which do not contain any volatile matter, *i. e.*, carbonized fuels.

Factors Influencing the Combustibility of Carbonized Fuels.

A very brief study of carbonized fuels is sufficient to show that the factors which determine their combustibility are more numerous and complex in character than is generally realized. The character of the fuel carbonized, temperature of carbonization, the rate of carbonization, and even the pressure under which the heating is effected, all play a part in determining the character and the combustibility of the resulting carbonized fuel. The effect of these various influences may be summarized as follows:

Influence of Character of Fuel Carbonized.

From the point of view of coke production, fuels can be roughly classified as fusible and non-fusible fuels. Fusible coals yield a coke which retains no trace of the shape and structure of the original coal. Non-fusible coals, on the other hand, yield a coke which approximates in shape to the original coal, and retains to a great extent its structure. (Charcoal can be quoted as an extreme example, as it has the cell structure of the wood from which it is produced. (See Figs. 12 and 13.)

Generally speaking, non-fusible fuels give a more combustible coke than do fusible fuels when carbonized under similar conditions.

Influence of Conditions of Carbonization.

This, however, is only a rough generalization, as conditions of carbonization play an extremely important part in determining the character of the fuel produced. Thus, to take an extreme case—by carbonizing wood under pressure a coke (not charcoal) can be obtained which retains no vestige of the original structure of the wood. But even under standard pressure, variations in the conditions of carbonization result in remarkable differences in the character and combustibility of the coke, and in this direction the two most important influences apart from the type of fuel used are the temperature and period of carbonization.

Effect of Temperature of Carbonization.

At first sight temperature might seem to be a factor of supreme importance in so far as the character and combustibility of a coke are concerned. Low temperature coke is much more free burning than high temperature coke, and it is generally assumed that the combustibility of the former is directly due to the volatile matter left in it by the use of a comparatively low carbonizing temperature.

A little consideration will show, however, that temperature is really not so important as it is generally considered to be. Cokes made at comparatively high temperature from splint or other non-fusible coals are comparatively free burning, while the authors, by carbonizing even fusible coals very slowly under suitable conditions, have succeeded in obtaining at high temperatures a fuel the combustibility of which is equal to that of any fuel they ever tested (*cf. infra*).

In the authors' opinion, temperature plays only a secondary part. The combustibility of low temperature coke is not due to the volatile matter, but to its structure. Many dry steam coals and also anthracites contain a volatile content of the same order as that of low temperature coke, but their combustibility in an open grate is very much lower. An examination of low temperature coke shows that it consists of a sponge-like mass with relatively thick cell walls. In the process of combustion the volatile matter in these walls is expelled. No fusion occurs, however, as the fusible constituents have been eliminated in the carbonizing process, and the expulsion of the volatile matter leaves a wall permeated with minute pores which enormously increase the surface exposed to the oxidizing gases and thus increase the combustibility.

In normal high temperature carbonization of a fusible coal the resinous constituents in the coal melt below the decomposing point, resulting in the formation of a thick viscid mass. As the temperature increases beyond the decomposition point, gas is evolved which blows the semi-liquid mass into a series of bubbles which run into one another and the ultimate result when the coke is "set" is the sponge structure referred to. A considerable portion of volatile matter is still left in the cell walls, however, and during the subsequent heating this has to penetrate to a great extent through a red hot mass of coke, and in its passage the hydrocarbons become decomposed, resulting in the deposition of graphitic carbon in the minute pores of the cell walls. Owing to the filling up of these pores the cell walls become more or less vitrified and are rendered impermeable to gases. The highly refractory incombustible character of high temperature coke is, in the authors' opinion, due to a great extent not to the low percentage of volatile matter, but to the non-porous character of the cell walls.

Effect of Period of Carbonization.

It is well known that the more rapidly a coal is carbonized at high temperatures, the more pronounced is the silvery-gray graphitic film referred to, while, on the other hand, if the coal is only gradually heated to the maximum temperature (as, for example, in a continuous vertical retort) the coke is less lustrous in appearance and more readily combustible.

If coal is uniformly heated, as, for example, in an internally heated retort, so that the center of the charge is at the same temperature as the portion nearest the walls, the secondary products of decomposition, instead of passing through a coked charge of continuously increasing temperature as in the case of high temperature carbonization, pass through zones of continually falling temperature and the secondary decomposition of the hydrocarbons on the minute pores of the coked material is therefore considerably reduced. The more slowly the charge is carbonized the slower is the evolution of the volatile matter and the more easily can it get away without being "cracked" or decomposed in its passage.

The ease of escape of the volatile matter is a factor of vital importance in determining the combustibility of the coke. Slow carbonization assists this in two ways: (1) As above by expelling the volatile matter so slowly that it can get away as it is formed, and (2) by converting a part of the fusible material of the coal substance into an infusible material. This, of course, facilitates considerably the ready escape of volatile matter.

The following experiment illustrates in an interesting manner the effect of a prolonged carbonizing period. A finely ground coking coal was briquetted without a binder, and the briquettes passed through an internally heated retort. Heating took place so slowly that a period of 72 hours was taken in bringing the charge to its maximum temperature of 1,000 deg. C. The briquettes retained their shape, but contracted during the process until the coke had a sp. gr. of 1.2, its structure consisting of a large number of minute cells with thin walls. The combustibility of this fuel was of the same order as that of charcoal. When once thoroughly ignited, a lump of this fuel could be removed from the fire, and if protected from draughts would continue to burn for several hours. In one test made a piece of a size 3 in. by 2 in. by 1½ in. made red hot and placed on a fireclay slab away from the fire, burned for over six hours until all that remained was a small piece 1x½x½ in.

Influence of Preliminary Treatment of Coal.

A very prolonged carbonizing period is, of course, not easy to reconcile with economic requirements on a commercial scale, but several methods are available which allow of the ready escape of the volatile matter. It can be done by (1) blending coal with coke breeze (Fig. 2), (2) blending caking with non-caking coals, or (3) preheating a portion of the coal to eliminate the resinous matter and mixing the resulting material in the correct proportions with raw coal.

All three of the above methods have been used by the authors in their works for several years, and similar processes have been worked out independently by other investigators, more especially by the Fuel Research Board, by Roberts (Trans. Inst. Min. Eng., 62, 9), and by Illingworth (Proc. S. W. Inst. of Engineers, 1921).

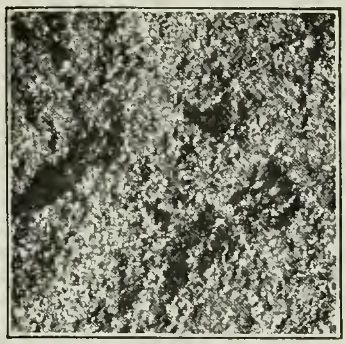
Mr. E. V. Evans and his collaborators of the South Metropolitan Gas Company have also worked out on a small commercial scale a process on similar lines. In this process, ground coke breeze and a cheap coal are mixed in such proportions that sufficient binding material is subsequently obtained from the coal. The mixture is afterwards carbonized at such a temperature that a compact mass results from the shrinkage that occurs, the temperature usually adopted being that of waste furnace gases—about 500-550 deg. C. The resulting product is hard and dense. It is an excellent smokeless fuel and is capable of withstanding the most severe conditions of handling and transport.

In order primarily to meet the economic requirements in large scale production of smokeless fuel, the authors have developed a method of preliminary briquetting of coal without a binder, and subsequent carbonization of the briquettes. In the case of most British coals swelling of the briquettes during carbonization can be prevented by the addition of 20 to 30 per cent of previously carbonized material to the coal, but in the case of a few coals containing a high proportion of resinous material it has sometimes been found necessary to adopt one or other of the alternative methods already mentioned.

The volatile products escape very readily from these mixtures and the preliminary treatment so facilitates the evolution and escape of the volatile matter that a hard, dense, smokeless fuel can be obtained practically at any temperature of carbonization from 500 deg. C. upwards. Even when made at the usual gas retorting or coke oven temperatures the coke produced can be ignited fairly readily and burns with absolute freedom in any type of grate.

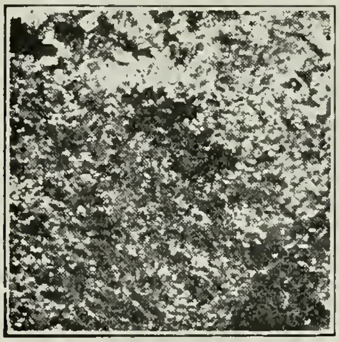
Influence of Structure.

A study of these carbonized briquettes throws a considerable light on the influence of structure on the combustibility of carbonized fuels. Research on this matter is still proceeding, and up to the present time it has not been found possible to make definite determinations of the relative combustibility of the various types of fuels that can be obtained by these processes. Sufficient has been done, however, to enable some of the principal factors involved to be determined, and these can be briefly outlined as follows:



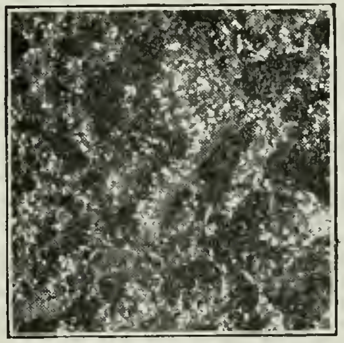
Low-temperature coke—Fuel Research Station. Natural size (Mixture of caking and non-caking coals.)

Fig. 8.



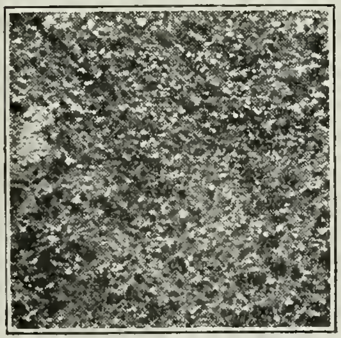
Gas coke. × 5.

Fig. 9.



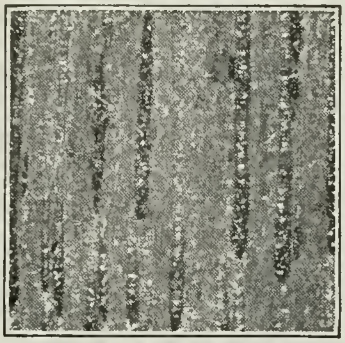
Vertical-retort gas coke. × 7.

Fig. 10.



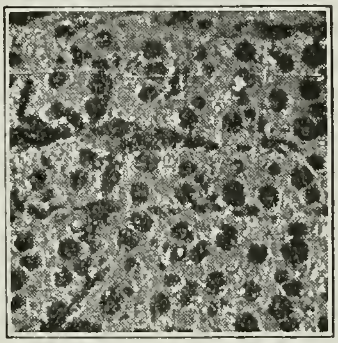
Blast-furnace coke. × 5.

Fig. 11.



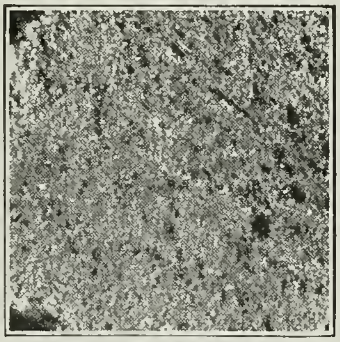
Bulk charcoal. Along the grain. × 5.

Fig. 12.



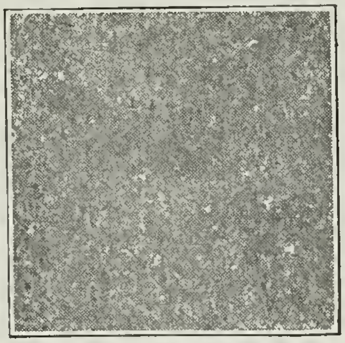
Bulk charcoal. Across the grain. × 10.

Fig. 13.



Pure coal briquette coke. Carbonised at 600° C. Coke made from mixture 40% coking and 60% non-coking coal. × 5.

Fig. 14.



Active carbon for vapour absorption. × 10.

Fig. 15.

(1) *Influence of Area of Surface*—The area of surface presented to the oxidizing gases is, of course, an important factor. Combustion can only be maintained if the area of incandescent surface exposed to the air is sufficient to maintain the temperature of a sufficient mass of the fuel above the point of ignition. The area of surface of blast furnace coke, for example, is much greater than that of a lump of anthracite, and the combustibility of the coke is therefore greater.

Generally speaking, the greater the area of surface of a fuel the greater the combustibility. Charcoal, with its highly developed cell structure, is a fuel possessing a very considerable area of surface per unit of mass, and is characterized by a high degree of combustibility.

Area of surface, again, is closely connected with degree of porosity and with the character and distribution of the pores.

(2) *Porosity*—The porosity of a carbonized fuel plays a vitally important part in connection with its combustibility, but here again it is not a question so much of the actual proportion of the pores as of their character. Very considerable differences exist between the degrees of combustibility of fuels of equal porosity, and on investigation it will be found that it is a question not so much of the total air space in a fuel as of the number of cells it contains, and of the ways in which these cells are interconnected.

In this connection it is important to consider the porosity of the cell walls. This factor is too often overlooked, and the factor of porosity is usually considered solely from the point of view of the air spaces surrounded by the walls.

In discussing the combustibility of low temperature coke, the authors have already touched upon this question. Their work leads them to the conclusion that the microscopic pores in a coke—say from the order of 1×10^{-3} cm. diameter downwards (*cf. infra*)—play an important part in determining its combustibility. It is therefore important to consider the character of the cell walls in investigating the question of porosity of coke.

(3) *Character of Cell Structure*—(a) Continuity of cell structure. The character of the cell structure of carbonized fuels was investigated by Thörner. He determined the combustibility of various blast furnace fuels, together with their porosity, and investigated the character of their cell structure by the microscopical examination of sections of the fuels. He found that the fuels which gave the best results in a blast furnace, viz., charcoal and Meiler coke, were characterized by a high degree of combustibility, and consisted, further, of cells more or less regularly arranged, which were joined to one another longitudinally. Furnace coke, on the other hand, consisted of separate unconnected cells, or groups of cells, the cells of which were composed of a dense and vitreous mass which did not allow of the passage of gas through it.

Carrick Anderson (J., 1896, 20), as a result of his investigations into the porosity of coke, confirmed this statement, and his work seemed to point to the existence of water-tight vesicles in coke. Later, Anderson and Roberts (J., 1899, 1102), in discussing the removal of nitrogen from coke by steaming, again emphasize the fact that coke "is a mass of cells, the walls of which are thoroughly vitrified and gas-tight" and therefore steaming would not be very efficacious in reducing the nitrogen in furnace coke as "except in so far as it burns away the carbon of the coke, it scarcely comes in contact with the nitrogenous constituents of the latter, protected as they are by this impervious coating."

Incidentally, Beilby in the discussion on this paper draws attention to the differences in the physical structure of splint, cannel, and coking coals, and to the difference in the carbonized products from these coals, and emphasizes the effects of the varying porosity of these fuels on the distillation products.

Taking a general view of this work, it might perhaps be too much to say that the cell structure of blast furnace coke is discontinuous; after all, the gases evolved in the later stages of distillation must get away, but there is reason to believe that the cells are connected by passages of small diameter as compared with the diameters of the cells.

Further, there is every reason to believe that the walls of these cells have been rendered vitreous and gas-tight by carbon deposition as already stated.

In the case of charcoal, on the other hand, the cells do extend longitudinally through the mass, while the authors have reason to believe that the continuity of the cell structure in fuels which have been briquetted prior to carbonization is much more pronounced than in the case of blast furnace or other coke made under normal conditions of high temperature carbonization.

This view is based upon certain properties of these fuels which are not customarily characteristic of high temperature coke, and which may be summarized as follows:

(1) The nitrogen left in the coke from these briquettes is very much lower than is the case with coke made in the usual way. The following analyses, which are typical of a large number of determinations that have been made, bring this point out very clearly:

	Raw coal	Mixture of raw coal and coke breeze	Coke from raw coal	Coke from briquettes made from mixture
Volatile matter	34.70	28.68	0.80	0.90
Ash	6.80	8.85	11.65	9.90
Sulphur	1.64	1.62	1.47	1.66
Nitrogen	1.38	1.58	1.44	1.02
Calorific value	15,500	13,500	11,950	12,350

It will be noted that although the nitrogen in the mixture of coal and coke briquetted is higher than in the raw coal, yet the nitrogen in the briquetted coke is only 1.02 per cent as compared with 1.44 per cent in the coke from raw coal. These results can be accounted for in one or two ways, depending on the method of formation of ammonia in the process of coal carbonization.

The generally accepted idea of the formation of ammonia in coal distillation is that it is a primary product formed by the decomposition of the nitrogenous matter in the coal, and that the extremely low percentage conversion is due to the decomposition of this gas in its passage through the hot coke. There is also another possibility, and that is that it is a secondary product, due to the action of nascent hydrogen on the solid nitrogenous material. Probably both reactions take place, the first at a low temperature and the second at a high temperature, particularly above 700 deg. C., where a marked increase in the quantities of hydrogen and of ammonia takes place.

Whatever the main method of ammonia formation, whether it is a primary or a secondary product, a continuity of cell structure would exert a favorable influence in the following respects: (1) In the former case, the evolution of ammonia would be accelerated, and decomposition retarded by the rapid escape of the volatile products from the heated material. (2) In the latter case, the nascent hydrogen would come into intimate contact with the nitrogenous material left in the porous solid mass, resulting in a conversion into ammonia.

As the result of a detailed series of experiments in another direction, the authors are of opinion that above 700 deg. C. the secondary formation is the predominant reaction, a conclusion which is to some extent confirmed by the above results.

(2) It has been found that coke made by the proces-

ses described above can be given marked powers of vapor absorption. Anti-gas carbon can be made by a modification of the above method which is capable of absorbing 10 per cent of its weight of heavy vapors.

A further modification can be made which has very strongly pronounced decolorizing power, and when the high sp. gr. of the fuel is taken into consideration in conjunction with the above properties (which are primarily dependent on area of surface) there seems every reason to believe that the cell structure of this material posssses a greater continuity than that of gas or furnace coke.

Effect of Size of Cells.

The dimensions of the cells play a considerable part in the combustibility of a fuel. Practically speaking, the porosity of a solid can be regarded from two aspects, viz.: (1) Cell space per unit volume, and (2) cell space per unit mass. A coke, for example, may be exceedingly voluminous, and may contain a large number of cells per unit of mass, but owing to its low apparent specific gravity may contain only a small number of cells per unit of volume. A coke of this type is obtained by customary processes of low temperature carbonization; an extreme example is shown in Fig. 1, in which a highly swollen coke is obtained with cells of large dimensions surrounded by very thin walls. The surface presented by such a fuel is very considerable, and its combustibility might be high, but on the other hand it is very fragile and will not withstand severe conditions of handling and transport, and of course would be of no use for blast furnace conditions.

The most desirable fuel would be a fuel as dense as possible, but containing a very large number of cells per unit of mass. Generally speaking, a fuel of apparent sp. gr. 1.2 with a porosity of 50 per cent would be more serviceable for general purposes than a fuel of app. sp. gr. 0.8 with the same proportion of cell space. In the former case, the cells would be exceedingly small, but the surface presented to the oxidizing gases would be so great that the combustibility would be even greater than in the former case.

The advantages of minute cells have been demonstrated in the following ways:

(1) It has been proved by an extensive series of experiments that the more finely ground the original coal mixture, the denser and the more combustible is the final product.

The influence of grinding is shown by some tests made with mixtures of caking and non-caking coals, submitted by the Fuel Research Board. These mixtures are so adjusted that the briquettes made do not expand on carbonization. In the case of the raw mixture which had been roughly crushed in a disintegrator, the briquettes made without a binder and subsequently carbonized presented the appearance of being covered with a mass of fairly large bubbles, giving a more or less irregular appearance to the briquette. As the mixture, however, became more and more finely ground these bubbles became smaller and less numerous and the surface became smoother and more uniform in apearance. At the same time the app. sp. gr. of the carbonized fuel uniformly increased. The sizing tests of the above mixtures are given below, together with the apparent specific gravity (no sizing test was made of the raw material).

It is evident that fineness increased the uniformity and density of the resulting product, due to the diminishing size of the cells, and extensive experiments over many years have proved to the authors that at the same time the combustibility of the fuel increases.

Table II.

	No. 2.	No. 3.	No. 4.	No. 5.
	Pct.	Pct.	Pct.	Pct.
Remaining on 20-mesh...	5.82	1.74	1.76	2.38
Remaining on 30-mesh...	11.37	1.62	0.68	0.32
Remaining on 60-mesh...	25.88	19.22	10.13	3.02
Remaining on 90-mesh...	22.03	32.15	35.22	27.67
Remaining on 120-mesh...	7.32	7.43	7.84	10.17
Remaining on 180-mesh...	2.22	2.51	2.84	4.14
Through 180-mesh...	25.36	35.33	41.53	52.30
Apparent sp. gr.........	0.933	1.031	1.034	1.103

(2) To produce activated carbon it is necessary to grind down to a size comparable with that required for dust firing. The cells in the resulting fuel become extremely minute, as is shown by Fig. 15. This fuel is easily the most combustible product produced by the authors' processes. Incidentally it has recently been shown by Harkins and Ewing (J. Amer. Chem. Soc., 1921, 43, 1787—1802) that pores of a greater diameter than 1.2 × 10^{-3} cm. have no absorptive action on vapors. The high absorptive powers of this carbon can only be satisfactorily accounted for by the assumption that it contains a large proportion of very minute pores.

(3) The surface offered by a material of this type permeated by minute cells, is enormous, and would be very much greater than that of a coke with a comparatively small number of cells enclosed by thick walls.

When heated in an oxidizing atmosphere the points of contact presented to the action of the oxygen would be very much more numerous than in the case of furnace coke, and, as has already been shown, this material continues to burn under conditions where the radiation and cooling losses are so considerable that ordinary furnace or gas coke would be extinguished in a few seconds.

Combustibility of Carbonized Fuels—Summary.

To summarize the above results:

By careful attention to the structure of a fuel it is possible to produce at high or low temperatures of carbonization a fuel of high degree of combustibility, high degree of hardness, and high apparent sp. gr.

The structure of this fuel has the following characteristics: High degree of porosity. Considerable area of surface per unit of mass. Pronounced cell structure. Pronounced continuity in cells. Large proportion of minute cells. Pronounced porosity of cell walls.

The Blast Furnace.

The third largest consumer of fuel in England is the blast furnace. In normal times the coke consumption in this country for the manufacture of pig iron amounts to about 12,500,000 tons per annum. The average consumption of coke per ton of iron is for the whole country about 25 cwt., and it is a remarkable fact that this figure is no lower, and is probably a little higher than it was 40 years ago.

When we consider the enormous progress that has taken place in other branches of industry during this period, and especially when we realize the amount of detailed scientific work that has been performed in connection with blast furnace practice, and the high degree of scientific control that has been introduced, it seems at first sight difficult to understand why this industry alone should have marked time for so long a period. A very slight acquaintance with the idiosyncracies of the blast furnace, however, is sufficient to bring home to the most ardent economist some of the difficulties involved in a saving of fuel. Koppers in his paper stated that "the blast furnace is still a mystery, and even today the blast furnace manager does not manage the blast furnace, but the blast furnace manages the manager." All that that unfortunate being wants is to be left in peace, and not be bothered with anything that will add to the complexities he has to face; and his attitude can be readily understood. He looks after his plant with just the same care as a chemist looks after a delicate quantitative analysis. Every ounce of material entering and leaving the furnace is carefully weighed and analyzed; every unit of heat that enters or leaves is accounted for, and from the data supplied by his chemical staff the blast furnace manager can draw up a chemical and thermal balance sheet of a character which is extremely difficult to criticize.

Further, the blast furnace manager has behind him the monumental work of Sir Lowthian Bell, whose classical researches on the chemical phenomena of iron smelting have dominated blast furnace practice for the past 50 years. Bell's work drove home with absolute and complete conclusiveness that in a blast furnace operating with coke as a fuel the indirect reduction of the Cleveland ore ceases when the relative proportions of CO and CO_2 are as 2:1.

Chemically, it is possible completely to convert CO and CO_2 by iron oxide, but at temperatures below 480 deg. C., this operation proceeds with such extreme slowness that in a blast furnace "the action would be delayed until the mineral reached a level in the blast furnace where the heat would resolve any CO_2 into CO" (J., 1890, 709).

This ratio $CO:CO_2 = 2:1$ at once fixes the thermal efficiency of furnaces working Cleveland ore at a minimum of 60 per cent reckoned on the available energy of the coke charged into it, and led Bell to state that it was "useless to hope to smelt a ton of gray iron from Cleveland stone yielding 41 per cent of pig iron metal with anything notably under 20½ cwt. of coke."

Assuming the ratio $CO:CO_2 = 2:1$, the chemical reactions in a blast furnace can be represented by the equation:

$$Fe_2O_3 + 9CO = 2Fe + 6CO + 3CO_2$$

which corresponds to a carbon consumption of 19.3 cwt. per 20 cwt. of pig iron produced, a figure which, after allowing for the impurities customarily present in furnace coke, agrees with Bell's figure of 20½ cwt. of coke. This figure meets with both the chemical and thermal requirements of the reaction.

This dictum, supported by researches of unquestionable accuracy and backed by nearly 50 years of accumulated experience, at once faces those who venture to suggest that a modern blast furnace is not an industrial machine of unquestioned perfection and that there is room for effecting economies in its operation. And yet, despite Bell's researches, despite the lessons of British experience, despite the failures that have attended the efforts of British fuel reformers in the past, the authors are still venturesome enough to suggest that the limit of fuel economy in British blast furnace practice has not been reached, but that substantial economies are still possible, and that even Cleveland ore will ultimately be smelted with as low a consumption as 12 cwt. of coke per ton of pig iron produced.

Fuel Consumption in Blast Furnace Practice.

Before proceeding to give reasons for this assertion it might be of interest to note some figures of fuel consumption in blast furnace practice that are available.

(1) *British Practice*—Clements (J. Iron and Steel Inst., 1920, I., 125) gives a valuable summary of results obtained in 17 British blast furnaces. These results can be summarized as in Table V.

N. B.—The low carbon consumption as compared with coke is due to the fact that both moisture and ash are included in the weight of coke charged into the blast furnace.

The differences in results obtained in different districts are to some extent accounted for by differences in the ore, but it will be noted that several instances exist which show a carbon consumption below Bell's theoretical minimum.

Table V.

District	Coke consumption per ton of pig iron in cwt.			Carbon consumption per ton of pig iron in cwt.			Furnaces
	Max.	Min.	Avg.	Max.	Min.	Avg.	
Middlesbrough ..	23.0	21.08	22.3	19.78	18.13	18.77	3
Midland	31.5	25.05	29	24.88	19.76	23.37	11
S. Wales	22	18	20	16.8	15.77	16.19	3

Turner ("Metallurgy of Iron and Steel," 3rd Edn., p. 205) quotes statements of S. Staffordshire managers that by working with soft coke in admixture with hard coke the fuel consumption was sometimes reduced to 16—17 cwt. in furnaces of only moderate size.

(2) *American Practice*—Howland (J. Amer. Inst. Min. Eng., Mar., 1916) gives detailed particulars of 26 American furnaces, all working with the same kind of ore, which showed very considerable differences in the coke consumption per ton of pig iron produced, the maximum being as high as 24 cwt. of coke per ton and the lowest 15 cwt. per ton, the carbon consumption being 20 and 12.6 cwt. respectively.

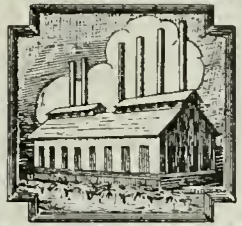
It is, therefore, not entirely a question of the ore used.

(3) *Charcoal Furnaces*—Lastly, charcoal furnaces, which are generally of much smaller dimensions than coke furnaces, show figures of carbon consumption which are startlingly low as compared with coke furnaces. Bell in fact quotes one case in which the carbon consumption was as low as 10.58 cwt. per ton of iron produced.

Combustibility of Coke as a Factor in Reducing Fuel Consumption.

The gap between some of these figures and the 19.35 cwt. which represents the minimum required to satisfy Bell's ideal is so considerable that the question arises whether some factor exists which was not taken into account in Bell's calculations. Howland definitely states that the only method of accounting for this considerable difference obtained in furnaces working the same ore is by assuming that the combustibility of the coke was far greater in the more efficient furnaces than in the less efficient ones. This opinion is confirmed by the results obtained in charcoal furnaces. Charcoal as a fuel is far more combustible than any type of coke, and it is significant that the fuel consumption in charcoal furnaces is lower than anything which has ever been obtained in coke furnaces. The interesting South Staffordshire results quoted also tend in the same direction.

Koppers considered this factor so important that he went so far as to advocate the use of coke carbonized at a temperature below 800 deg. C., so as to secure a more combustible fuel. (The authors, while they agree with Koppers as to the necessity for a combustible coke, do not consider the method suggested of carbonizing below 800 deg. C. to be a satisfactory solution.)



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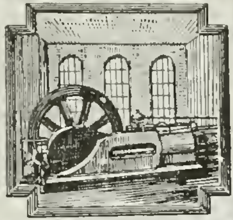

Calculating Heat Losses in Furnaces

A New Method For the Determination of the Heat Losses Due To Incomplete Combustion.

*By O. I. HANSEN, M. E., Copenhagen, Denmark

OUR investigations on furnaces in boilers has made it evident that in far more cases than it is generally expected unburned gases are present in the flue. This seems to be the case both in ordinary steam producing boilers as well as in boilers for domestic heating purposes and even in cases where the contents of carbonic acid does not exceed 8-9 per cent.

In ordinary furnace installations the unburned gases are composed of carbonic oxide alone or carbonic oxide mixed with hydrogen or methyl hydride or both. While the percentage of carbonic oxide may vary considerably the amounts of hydrogen and methyl hydride always are limited to quite small quantities, which are rather difficult to examine directly.

Drawing gas out of coal as it is done in ordinary gas retorts we get approximately 5 cubic feet gas per one lb. of coal. As part of this 2.5 cu. ft. is hydrogen and 1.6 cu. ft. methyl hydride. Of course the processes occurring in a furnace is not the same as in a gas retort but generally speaking, we are able to treat both processes in the same way.

Provided we use coal of 12,600 Btu per one lb. coal, heating value, a perfect combustion will require 168 cubic feet of atmospheric air (carbonic acid 14 per cent) we conclude that the flue gas as a maximum contains:

$$\frac{2.5}{168} \times 100 = 1.48 \text{ or appr. } 1.5 \text{ per cent } H_2$$

$$\frac{1.6}{168} \times 100 = 0.96 \text{ or appr. } 1.0 \text{ per cent } CH_4$$

For just short periods the amounts may be larger, but as a fair approximation for this estimate the maximum quantities are 1.5 per cent H_2 and 1.0 per cent CH_4.

We exclude from our investigations quantities of heavy carburetted hydrogens (C_nH_m) which very seldom are present in the flue gas in a larger percentage than 0.1 per cent, and we are quite unable to measure such small quantities, except in laboratories.

It is under ordinary circumstances very difficult to apply the results attained through the analysis by means of an ordinary Orsats Apparatus for the determination of the heat losses due to incomplete combustion. The apparatus is very practicable as long as it is only used in order to determine the percentage of carbonic acid, but several difficulties arise when it comes to the determination of oxygen and carbonic oxide.

The absorption of oxygen in pyrogallic acid is generally so slow and intricate that it is unpracticable for ordinary purposes. Furthermore the amount of this acid contained in the ordinary Orsat pipette is so small and will only allow for about 50 analyses, and if kept in the bottle the acid becomes impoverished within only a few days.

The process would be quicker by testing with phosphorus than by testing with pyrogallic acid, but the determination of oxygen proves to be impracticable whenever the flue gas contains only small quantities of heavy carburetted hydrogens as the phosphorus then is not so certain to absorb all oxygen.

The determination of carbonic oxide is generally done by means of hydrochloric or ammoniacal solution of cuprous chloride. This way of determining the amount of carbonic oxide is even more slow and uncertain than the determination of oxygen because cuprous chloride absorbs the amount of oxygen, which eventually has not been absorbed by the pyrogallic acid, further does the solution of cuprous chloride absorb very slowly and there is finally the possibility for this solution to give up part of the carbonic oxide already absorbed.

Besides carbonic oxide the flue gas may contain hydrogen or methyl hydride as already mentioned, a fact, which has not always been the subject of investigators' attention.

It is of very great importance to have the sample of flue gas at an invariable temperature throughout the trial, because a deviation in temperature of only 3 deg. Centigrade will cause an error in the determination of the volume amounting to one per cent and the amount of unburnt gases in the flue gas is in many cases even less than one per cent.

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*Translated and transcribed into American Units for heat and spare by F. V. Hangsted, M. E.

In order to avoid errors to this effect the following should be observed. The apparatus for analyzing the flue gases should be brought to the spot where the trial is to take place about an hour before the work starts in order to make the temperature of the spot and the temperature of the apparatus balance. After being taken into the apparatus the sample must be given sufficient time to adopt the temperature of the latter. Having observed this the actual time for making each separate analysis must be as short as possible in order not to allow for any greater deviation in temperature during that period.

In order to get a quick result in determining all losses of heat due to unburned gases without using the troublesome and slow absorption method, we applied a capillary tube made out of platinum and burned our sample of flue gas in this after having withdrawn its contents of carbonic acid.

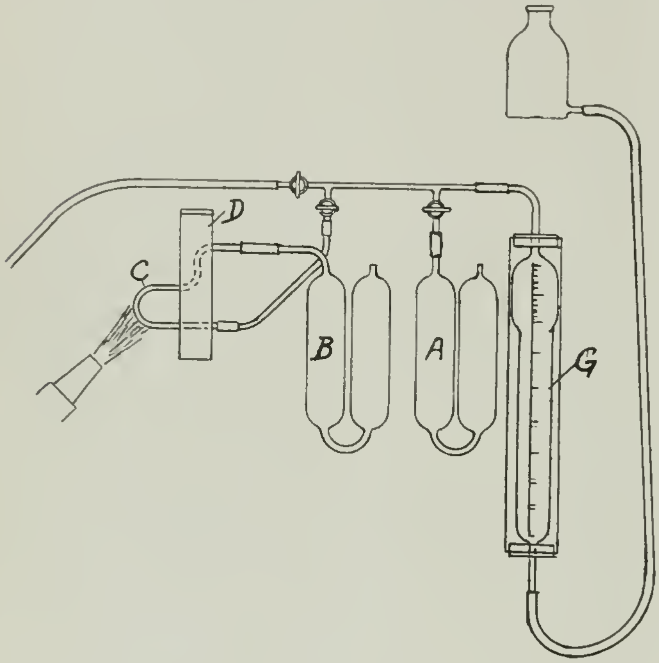

Fig. 1.

After a long line of experiments we concluded in the apparatus as shown below:

Our apparatus is an ordinary Orsat apparatus with two absorption pipettes, one (A) containing solution of caustic potash and the other (B) water. The platinum capillary tube (C) is kept cool on part of its length through the vessel (D) containing water. A gasoline heating lamp is applied for the heating of (C).

The application of this apparatus is as follows:

After having drawn a sample of flue gas of 100 cubic centimeter volume into the graduated measuring tube (G) we examine the contents of carbonic acid through absorption in (A). After having done this the gas is driven slowly through the capillary tube (C), which is heated, and passes over into (B), where it is cooled. When all of our sample is contained in (B) the heating lamp is removed from (C), which cools off quickly. The gas is then driven back into the graduated measuring tube (G) and we are able to measure any resultant contraction. In order to be quite certain about the result it is recommended that this operation be repeated for each sample. Then make a determination of the amount of carbonic acid, which has been produced through the combustion in the capillary tube, and our analysis is finished. It is proved to be possible to make this analysis in 5 or 6 minutes.

It is of importance to heat the capillary tube to a sufficiently high temperature. The use of an ordinary spirit lamp has been tried for this purpose, but though carbonic oxide and hydrogen burned, methyl hydride in many instances did not burn until we applied a gasoline heating lamp.

In some of our experiments we used a 50 per cent mixture of glycerine and water in the pipette (B) in order to avoid any absorption of carbonic acid in this pipette, but as it proved to be impossible to prevent small quantities of this mixture to slip over into the platinum capillary tube and develop a large amount of carburetted hydrogen during the combustion, we realized that this mixture was unserviceable.

For the following calculations we presume the flue gasses composed as designated by the following percentages by volume:

CO_2 per cent oxygen
O_2 per cent carbonic acid
CO per cent carbonic oxide
H_2 per cent hydrogen
CH_4 per cent methyl hydride

besides nitrogen and water vapor, which is immaterial in this estimate.

We further presume that after our first absorption the percentage (cubic centimeters) of carbonic acid measures CO_2, after the combustion in the capillary tube the contraction is c, and the last determination of carbonic acid shows a percentage by volume of co_2.

At the combustion in the capillary tube the following reactions took place:

For CO burned to CO_2
$CO + \frac{1}{2} O_2 = CO_2$, one cubic centimeter of CO requires ½ cubic centimeter O_2 and produces one cubic centimeter CO_2, the resultant contraction is ½ cubic centimeter.

For H_2 combining with O_2 the reaction is
$H_2 + \frac{1}{2} O_2 = H_2O$, one cubic centimeter H_2 combines with ½ cubic centimeter O_2 and produces one cubic centimeter H_2O, the resultant contraction is 3/2 cubic centimeters.

For CH_4 burned to CO_2 and water the reaction is $CH_4 + 2\ O_2 = CO_2 + 2H_2O$, one cubic centimeter CH_4 requires two cubic centimeters O_2 and produces one cubic centimeter CO_2 and 2 cubic centimeters H_2O, the resultant contraction is two cubic centimeters.

The total contraction is hence:

(1) $c = \frac{1}{2}\ CO + 3/2\ H_2 + 2CH_4$, and the last determination of carbonic acid shows

(2) $co_2 = CO + CH_4$.

c and co_2 are determined by the analysis, but for the determination of CO, H_2 and CH_4 we have only two equations.

The determination of the percentages of each separate gas would require an examination of the amount of oxygen consumed at the combustion in the capillary tube. As we do not know the percentage amount of oxygen present in the flue gases, this examination would require the removal of all oxygen and the aspiration of a certain volume of atmospheric air before we let the sample pass through the capillary tube, where the combustion takes place, after this we would have to remove all oxygen once more and would then be able to determine the amount of oxygen consumed in the combustion.

This method however is too intricate for ordinary purposes and the gain in exactness of our final result is minimal, partly due to the fact that before drawing in atmospheric air we would have to discharge about 50 per cent of our sample, which means that the inaccuracy in our observations would be doubled. We therefore worked out a method for the determination of the heat losses based on the contraction (c) and the amount of carbonic acid produced during the combustion (co_2).

The available heating values per one cu. ft. of CO, H_2 and CH_4 are as follows:

CO,	342.3 Btu
H_2,	289.8 Btu
CH_4,	954.2 Btu

Contemplating these figures and the two equations (1) and (2) we see that in having determined certain values of c and co_2 the heat losses will reach a maximum if the flue gas contains only carbonic oxide and methyl hydride and no hydrogen and the heat losses will reach a minimum in case the flue gases contains hydrogen and carbonic oxide and no methyl hydride.

Taking each of these two cases separately we find:
When $H_2 = O$ (heat losses at a maximum)

$$\begin{aligned} c &= \tfrac{1}{2}\,CO + 2CH_4 \\ co_2 &= CO + CH_4 \end{aligned}$$

Or we may write

$$\left.\begin{aligned} CH_4 &= 1/3\ (2c - co_2) \\ CO &= 2/3\ (2co_2 - c) \end{aligned}\right\}\ (\propto)$$

When $CH_4 = O$ (heat losses at a minimum)

$$\begin{aligned} c &= \tfrac{1}{2}\,CO - 3/2\ H_2 \\ co_2 &= CO \end{aligned}$$

Or we may write

$$\left.\begin{aligned} H_2 &= 1/3\ (2c - co_2) \\ CO &= co_2 \end{aligned}\right\}\ (\beta)$$

In the following we use the symbol w to designate the actual heat losses, the symbol $w\propto$ to designate the maximum and $w\beta$ the minimum heat losses, we then find:

$$w\propto = 3.42\ CO - 9.54\ CH_4$$

Inserting the values of CO and CH_4 from ($\propto$)

(3) $w\propto = 4.08\ c - 1.38\ co_2$

In the same way the minimum

(4) $W\beta = 1.93\ c + 2.45\ co_2$

We then find w as the intermediate between $W\propto$ and $w\beta$

(5) $w = \tfrac{1}{2}\,(w\propto + W\beta) = 1.91\ co_2 + 3.01\ c$

In doing so the error at a maximum would be

(6) $dw_{max} = \tfrac{1}{2}\,(w\propto - w\beta) = 0.535\ (2c - co_2)$

The heat losses calculated per one lb. of fuel is

(7) $W = Fw = (3.01\ c + 1.91\ co_2)$

Where F is the cubic ft. volume of flue gas produced per one lb. of fuel.

$$F = \frac{C - C'}{CO_2 - co_2} \times \frac{359.5}{12} = \frac{C - C'}{CO_2 - co_2} \times 29.93$$

Where

C is percentage by weight of carbon in the fuel

C' is percentage by weight of carbon in the ashes

co_2 and CO_2 are percentage by volume of carbonic acid by 0° Centigrade and atmospheric pressure (29.922").

Formular 7 will give the exact heat losses in case the flue gas contains only CO or CO mixed with equal quantities of H_2 and CH_4. Our tests however have shown that in using gassy fuel we generally find both hydrogen and methyl hydride together with carbonic oxide, in such cases where we were able to measure any amount of unburnt gases at all. This indicates that under ordinary conditions the error will generally be much smaller, than the above estimated maximum error.

Using coke one would be apt to think that we should only find CO_2 and CO in the flue gas. Our tests however have shown the presence of measurable quantities of f. inst. H_2 in furnaces using coke. This is probably due to the fact that the moisture does not evaporate all at once but part of it is decomposed into H_2 and O, or the presence of H_2 may be due to a certain percentage of vapor in the atmospheric air.

The heat losses due to unburnt gases in furnaces using coke might be estimated by means of the same formular (4).

The heat losses per 1 lb. of fuel is hence

(8) $W = Fw = F\ (1.93\ c + 2.45\ co_2)$.

The validity of formular 7 will be appreciated if we compare its inaccuracy with the error in observation on the Orsat apparatus. An experienced man will be able to read the volume with an error not larger than 0.1 cubic centimeter, and if we further take into account a small deviation in temperature we may estimate this error to be 0.2 cubic centimeter.

Differentiating 7 we find

$$dW = F\ dw = F\ (3.01\ dc + 1.91\ dco_2)$$

In this equation dco_2 will not have its maximum value at the same time as dc has it, therefore the following three cases should be investigated.

$$dc = -0.2;\ dco_2 = \begin{cases} 0 \\ -0.2 \\ -0.4 \end{cases}$$

$$dc = -0.2;\ dco_2 = \begin{cases} -0.2 \\ 0 \\ -0.2 \end{cases}$$

$$dc = 0;\ dco_2 = -0.4$$

The cases:

$$dc = \pm 0.2;\ dco_2 = 0$$

will show the biggest errors, we find:

(9) $dW_{max} = 3.01 \times 0.2\ F = 0.602\ F$, Btu per 1 lb. of fuel.

Calculating this error as percentage of the heating value of the fuel, we find

$$dW_{max}\,\frac{100}{B} = 0.602\,\frac{F}{B}\,100 \text{ per cent.}$$

From (6) we find

$$dW_{max} = F\ w = 0.535\ (2c - co_2)\ F,$$

and as percentage of the heating value

$$dW_{max}\,\frac{100}{B} = 0.535\ (2c\,\frac{F}{B}\,co_2) - 100, \text{ per cent.}$$

According to these results we are now able to estimate the proper limits for the errors in each separate case.

We now want to show an example, presuming that the flue gas is actually composed of

CO_2,	14 per cent by volume
CO,	2 per cent by volume
H_2,	0.4 per cent by volume
CH_4,	0.6 per cent by volume

Calculating the actual values of c and co_2

$$c = \tfrac{1}{2} \times 2 + 3/2 \times 0.4 + 2 \times 0.6 = 2.8$$
$$co_2 = 2 + 0.6 = 2.6$$

Then the actual loss in heat will be

$$2 \times 3.423 + 0.4 \times 2.898 + 0.6 \times 9.542 = 13.73 \text{ Btu.}$$

Calculating the heat losses according to 5

$$w = 1.91 \times 2.6 + 3.01 \times 2.8 = 13.39 \text{ Btu.}$$

The actual error in using 5 is then

$$13.73 - 13.39 = 0.34 \text{ Btu.}$$

Calculating the maximum error according to 6 we find

$$dw_{max} = 0.535\ (2 \times 2.8 - 2.6) = 1.61 \text{ Btu.}$$

The maximum error in observation is as shown above 0.60 Btu per one cubic ft. of flue gas or in this case just twice as big as the actual error in calculation.

We will now estimate the error as a percentage by the heating value of the fuel.

Using coal with a heating value 12,600 Btu and 192 cu. ft. of flue gas per one lb. of coal, then the actual heat losses will be:

Using the figures from the example above

$$13.73\ \frac{192}{12{,}600}\ 100 = 21 \text{ per cent of the heating value}$$

of the coal.

Inserting the result attained by 5 in the same way

$$13.39\ \frac{192}{12{,}600}\ 100 = 20.5 \text{ per cent of the heating}$$

value of the coal.

The maximum error in calculation is

$$1.61\ \frac{192}{12{,}600}\ 100 = 2.46 \text{ per cent.}$$

But the actual error in calculation is only

$$0.34\ \frac{192}{12{,}600}\ 100 = 0.50 \text{ per cent.}$$

And the maximum error in observation is

$$0.60\ \frac{192}{12{,}600}\ 100 = 0.92 \text{ per cent.}$$

The error in calculation will only reach the above estimated maximum value in case the flue gases besides carbonic oxide contain either methyl hydride alone or hydrogen alone. But our investigations have proved as already mentioned, the assumption that carbonic oxide is present either alone or together with both methyl hydride and hydrogen in flue gases from gassy fuel. This indicates that in most cases the actual error in calculating according to the above given method is less than 0.5 per cent of the available heating value of the applied fuel and generally even smaller than the probable error in observation.

In case the flue gases have a high percentage of carbonic acid along with a measurable amount of unburnt gases it is quite probable that the oxygen present in our sample will not be large enough to accomplish a perfect combustion in the capillary tube. We would then have to take a certain amount of atmospheric air into the apparatus, which again may require the discharge of a certain part of the sample in order to make room for the air.

For instance if the fuel is composed as follows:

Percentage by weight of carbon	76
Percentage by weight of oxygen	8
Percentage by weight of hydrogen	5

And the flue gas is composed as follows:

Percentage by volume of CO_2,	15
Percentage by volume of CO,	3
Percentage by volume of CH_4,	0.5
Percentage by volume of H_2,	0.5

Then the amount of O_2 will be:

$$O_2 = 20.9 - CO_2 \times 1.125 - CO \times 0.73 + CH_4 \times 0.457 + H_2 \times 0.187,$$

inserting the values of CO_2, CO a. s. f.

$$O = 20.9 - 15 \times 1.125 - 3 \times 0.73 + 0.5 \times 0.457 + 0.5 \times 0.187$$

$$O_2 = 2.13 \text{ cubic centimeter.}$$

Contemplating the reactions during the combustion in the capillary tube as already mentioned, we are able to calculate the amount of oxygen necessary for each reaction, we find:

3 cubic centimeter of CO
requires $0.5 \times 3.0 = 1.5$ cu. centimeter O_2

0.5 cubic centimeter of CH_4
requires $2.0 \times 0.5 = 1.0$ cu. centimeter O_2

0.5 cubic centimeter of H_2
requires $0.5 \times 0.5 = 0.25$ cu. centimeter O_2

After having absorbed the percentage of CO_2 (15 per cent) we are able to take into the apparatus

$$15\ \frac{20.0}{100} = 3.13 \text{ cubic centimeter oxygen}$$

for the combustion then is available

$3.13 + 2.13 = 5.26$ cubic centimeter oxygen, which is ample in this case, as only 2.75 cubic centimeter is required.

In order to give a final conclusion of what our investigations as described in this article have accomplished, we may say: It is possible to make a calculation of the heat losses due to the presence of unburnt gases in the flue, which is exact enough for ordinary purposes. This calculation leads to a determination of the heat losses, which gives a far more exact result than the methods formerly used. These methods did not generally indicate but the percentage of carbonic oxide and the exactness was even very doubtful.

As long as our investigations are only made in order to determine the quality of the combustion in the furnace and not for the purpose of examining the evaporation, our device is very practicable, because within a few minutes it determines whether or not any unburnt gases are present in the flue gas, and the apparatus is always ready for use, this is a great advantage compared with the ordinary Orsats apparatus containing pyrogallic acid and cuprous chloride as these solutions must be renewed quite frequently.

Among those numerous cases in which our method has proved to be very advantageous its application on continuous running furnaces in boilers for domestic heating has been especially successful. Once running, it is very difficult in some cases even impossible to determine directly the amount of heat used efficiently in these furnaces. The determination of the efficiency in such cases can be made indirectly through a deduction of all heat losses from the amount of heat actually produced by a perfect combustion of the fuel. It is therefore of great importance to be able to determine all heat losses with the largest possible exactness, and as to the heat losses due to incomplete combustion this can be accomplished through the method described in this article.

Pulverized Coal in the Steel Plant

Application of Pulverized Fuel to Open Hearths, Soaking Pits, Heating Furnaces, Sheet and Pair Furnaces and Some of the Results Obtained.

By W. H. SEARIGHT

POWDERED coal has made such rapid strides in the last few years that it must be taken into account not only for the generation of steam in power plants, but also for its varied uses in the steel industry.

This form of fuel has been tried in the following types of steel mill furnaces: open hearth, soaking pits, heating furnaces, sheet and pair furnaces, annealing furnaces, and several other types found in some mills.

From the foregoing list it can be readily seen that a thorough study of the combustion of coal should be made, as greater economies can be effected when the laws that govern this method of firing are known. The burning of coal is similar to that of oil or gas, and the greater the degree of pulverization (and this is especially true of low ash coals) the more nearly the combustion approximates liquid and gaseous fuels.

Two important characteristics of the fuel to be burned must be taken into account, the volatile content of the coal and the ash content. In the proper designing of combustion chambers, these items receive first consideration.

It is not necessary for coals to be high in volatiles and low in ash. Anthracite culm, which is naturally low in volatiles and extremely high in ash, can be readily burned. Even Rhode Island anthracite, when pulverized and used for the generation of steam, exceeds all expectations.

Open Hearth Furnaces.

The progress made by powdered coal in its application to the open hearth furnace has been slow when compared to its progress in other directions. The principal reason for this condition can be traced directly to the lack of interest shown by the majority of furnace operators who are ignorant of the proper methods of firing when powdered coal is used. Nearly every failure in open hearth furnaces has been due to extreme temperatures burning out the roof, side walls and end walls. Therefore it remains for the fuel to be properly controlled as gas and oil are. Besides this, another serious objection to the use of powdered coal in this type of furnace confronts us.

In order that the large amount of dust which is carried into the slag chamber be removed, the furnace must be built in such a way as to accomplish this removal quickly and easily. It is also well to provide for extra large flue areas in the checker work. The operator does not like to see his furnace undergo such radical changes as he invariably expects to have trouble getting out his heats with powdered coal. This pessimistic attitude is due largely to his unfamiliarity with this form of fuel.

However, some open hearth furnaces have been fired with powdered coal successfully. In one of these cases the average fuel consumption based on several months' run was approximately 500 pounds per ton with all metal charged cold. Another record run over a period of one month was a production of 3,300 tons of ingots with a fuel consumption averaging 441 pounds per ton of metal and a maximum fuel consumption of 700 pounds per ton. The melting loss of the above run was from 8 per cent to 10 per cent.

Powdered coal shows a distinct advantage over producer gas fired furnaces as to fuel consumption, a good average for a producer fired furnace being the equivalent of 600 pounds of coal.

Soaking Pits.

Powdered coal has been used in the operation of soaking pit furnaces. These pits are of the non-regenerative type having a capacity of 260 tons per day charging 300-pound ingots. When the ingots are charged cold, which is usually the case, the fuel consumption approximates that of a reheating furnace of the non-continuous type.

Heating Furnaces.

Because of the problem of ash disposition on entirely satisfactory type of continuous heating furnace has been designed. Furnaces of the continuous billet type now using powdered coal have been built for some other method of firing. Nearly all have short combustion chambers which allow only a small percentage of ash to be precipitated in molten form, the balance being carried along in the flue gases. As the velocity of the gases decreases the majority of the ash is deposited throughout the length of the furnace and the flues in the form of dust.

In furnaces used for heating short billets the accumulation of dust and slag is objectionable. The labor which this entails would frequently offset some of the advantages of coal in the powdered form. However, when slabs occupy the entire width of the furnace the accumulation does not become so troublesome.

Varying results in fuel consumption have been obtained from different types of continuous furnaces. The range is from 90 pounds to 190 pounds of coal per ton of billets. The low figure was obtained by charging billets at 1,000 deg. F., but an average fuel consumption of 150 pounds per ton was made with a good grade of coal in a furnace designed for gas firing.

There are a large number of heating furnaces of the "in and out" type in operation, using pulverized coal as fuel. Although the dust from the ash has been troublesome at times, operators are most enthusiastic over the results obtained as compared with hand firing. In furnaces of this type one of the great economies effected by the use of powdered coal is the reduction of oxidation losses. When steel prices were at the peak, the saving at a plant operating a heating furnace for rerolling scrap was several thousand dollars in oxidation losses alone. The cost of pulverizing coal at this plant was abnormally high because of the small output used. Nevertheless the statement was made that no other method of firing would be considered, even though the cost of pulverizing was doubled. The savings in fuel after deducting the cost of pulverizing (all items including overhead taken into account) gave a good return on the investment; and when the savings from reduction of oxidation losses were added, the result was exceptional. A waste heat boiler was used in conjunction with this furnace. In general terms, a reduction of approximately 75 per cent is made in oxidation losses with powdered coal firing.

Sheet and Pair Furnaces.

The sheet mill industry has recognized the many operating advantages of powdered coal. It was first adapted to furnaces designed for hand firing and the results were very unsatisfactory. Even with coal of low ash content, a large amount of dust was carried into the heating chamber, settled on the sheets and was rolled into their surface, spoiling them and ruining the rolls. In some cases it was necessary to sweep the ash from the sheets upon their removal from the furnace. Even this method, however, did not take care of the ash that settled between the sheets when they stood against the wall.

The adoption of a large combustion chamber not only made possible the proper combustion of fuel, but made allowance for the expansion of the gases and the precipitation of the ash before it reached the working chamber, thus reducing the number of sheets spoiled by settling of the ash.

The use of the individual powdered coal bin, with its own coal feeders, burners and blower for each unit of one sheet and one pair furnace, gaves a greater flexibility of control and reduces the chances of shutdown as far as fuel is concerned.

The fuel consumed in sheet and pair furnaces will run from 26 pounds to 325 pounds per ton of sheets produced. Furnaces making high grade sheets over a period of several months average about 300 pounds of coal per ton of sheets.

Annealing Furnaces.

Powdered coal has been applied only to sheet and tin plate annealing furnaces of the "in and out" type. In its early application the design of the furnace then in use decided the location of the burner, as well as the size of the combustion chamber. When new sheet mills were built with the intention of utilizing powdered coal, the proper design and construction of combustion chambers was possible. Each chamber is served, generally, by separate equipment, thus enabling a more accurate control of flame and temperature. The size of the furnace, the amount charged and the quality of the sheets produced are some of the determining factors of fuel consumption, which varies from 150 pounds to 400 pounds per ton of sheets.

Conclusion.

The foregoing facts give a brief outline of the results that can be expected by the adoption of powdered coal. The advantage derived from this type of fuel is largely a reduction in coal consumption, although all other factors must be given fair considered.

DISINTEGRATION OF BLAST FURNACE LININGS

By L. O. Brightbill

Disintegration of blast furnace linings has been a problem of much worry to many furnace superintendents.

Some time while using the same material, one blast will be of long duration and then again very short.

This is blamed sometimes on the mason work; other times on the quality of brick. But personally I believe that most of this is due to the blowing in.

I have in mind a furnace that was started off at a rapid gate. Within a few weeks the walls were practically useless. Again the blast ate out the lining, so now I consider a happy medium between the two to be the best.

One furnace under my charge ran sixteen years with the same lining. This furnace used a very high zinc ore. Being a small furnace and working cool stock line the "oxide zinc" formed a coating on the walls, which was a protection to the walls. After this same furnace had been enlarged, the zinc worked exactly opposite, helping to cause a disintegration of the lining, lodging in downcomers and flues.

Some times the furnaces will scaffold on one side, causing the blast to go up the opposite side, making it wear out in a very short time.

I have noted particularly when the stock is good and dry that is used in blowing in a furnace, I have invariably had good success with the entire blast. But when the ore is wet, causing it to cake on the wall, in blowing in I have had more or less trouble with that blast, the lining lasting only a short while.

UNIVERSITY OFFERS COURSE IN METAL MARKETING

To acquaint students with the fundamental facts underlying the minerals and raw materials situation the school of commerce, accounts and finance of New York university, New York, has scheduled a course for the coming school year which will deal with this subject. The character and source of supply, the methods and cost of preparing materials for market and their relation to other lines of business are general topics to be given consideration. Dr. Ernest Lilley, geologist and mining engineer, is to be the lecturer.

Some of the discussions which will be of interest to the iron and steel industry will be the character of coal reserves and resources, problems of the American coal, coke and coal tar industries and the water and super power systems. During the spring term which will be devoted to the commercial geology of the metals the class will consider, under the iron group, the mining and preparation of iron and steel, world problems in iron ore conservation and utilization, the major and minor alloy bases. Flux materials, refractories and insulators and abrasives will occupy the attention of the process materials section. One of the last groups will take up the nonferrous metals from the standpoint of the American copper industry, problems of the lead and zinc industries, major imported metals as tin and nickel and the minor metals.

The course is divided into two sections, one being a fall and the other a spring term. Classes are to be held at the Washington square division of the university.

NEWS OF THE PLANTS

The Maryland Steel Rolling Company, Baltimore, Md., has acquired the plant and business of the Trenton Steel & Wire Company, Mackenzie Street and Inghan Avenue, Trenton, N. J., for a consideration said to be about $150,000. The company will be merged with the parent organization, and raw material including hot rolled strip will be furnished in the future from the Baltimore plant. Plans are under way to increase the capacity of the last noted mill, and 16 new rolling machines with auxiliary equipment will be installed. This will give the Baltimore works an annual output of approximately 20,000 tons. It is also planned to increase the capacity of the Trenton works in the future, and it is expected that certain operations now being carried out at the Baltimore plant will be removed to the new location at Trenton. James Robinson, at one time president of the Keystone Rolling Mill Company, Pittsburgh, Pa., has been appointed general manager of the Trenton plant. Stanton Haines, formerly manager of the Trenton Steel & Wire Company, will be mill superintendent. Rubin S. Baldwin, manager of the Maryland Steel Rolling Company, will have supervision over the Trenton works.

The Brown Steel Company, 480 Neilston Street, Columbus, Ohio, manufacturers of steel products, will soon commence the construction of a new plant addition, adjacent to its present works. The structure will be one-story, 275x305 feet, and equipped for general steel working. It is estimated to cost about $150,000, including equipment. Charles W. Brown is general manager.

Horace T. Potts & Company, 316 North Third Street, Philadelphia, Pa., manufacturers of iron and steel products, will break ground at once for the erection of a new plant on property recently acquired on East Erie Avenue, extending from D to F Streets. The works will comprise a number of one-story buildings, with two main structures, 120x192 feet, and 75x370 feet, respectively, to be equipped with punches, shears, saws and general iron-working machinery, as well as traveling cranes and other handling equipment. The new plant will cost about $500,000.

The Washington Iron Works, Inc., Seattle Boulevard and Norman Street, Seattle, Wash., has plans under way for the construction of a large addition to its plant, to comprise a number of buildings, averaging from 50x100 feet to 130x450 feet, equipped for general iron working. The new plant is estimated to cost in excess of $500,000, and construction will be commenced at an early date. Gerald Fink is president.

The Palmer Steel Company, 316 High Street, Holyoke, Mass., recently organized to manufacture iron and steel products, has awarded a building contract and will commence the immediate erection of the initial unit of its proposed new plant on property lately acquired at Williamsett. It will be about 70x330 feet, equipped for steel fabricating and other work, and is estimated to cost about $75,000. Earl Palmer is president, and Wayne F. Palmer treasurer.

The National Enameling & Stamping Company, 411 Fifth Avenue, New York, N. Y., has plans in progress for the construction of a large addition to its steel mill at Granite City, Ill. The work will consist of six black steel sheet mills, galvanizing sheet mill, and a 72-inch jobbing mill, designed to provide for an additional output of about 5,000 tons of sheet steel per month. The plant will give employment to about 700 additional operatives, and it is expected to cost close to $100,000. George W. Niedringhaus is president.

The Youngstown Steel Company, Youngstown, Ohio, will soon break ground for the construction of a new mechanically operated puddling plant, estimated to cost approximately $1,500,000, including equipment. The new mill will be designed to operate under a special process, whereby considerable mechanical labor will be eliminated. It will give employment to about 200 men. The company also has preliminary plans under consideration for the construction of a new blast furnace with capacity of about 500 tons. The expansion plans provide for extensive increase in operations at the company's works at Warren, Ohio. H. Z. Bixler is company engineer in charge.

The Chapman-Price Steel Company, Shelby Street, Indianapolis, Ind., is having plans prepared for the construction of a large addition to its local mill for extensive increase in capacity. The project will include a number of one-story buildings for different features of steel manufacture, and is estimated to cost approximately $500,000, including machinery. Bids for the work will be called in the near future. Niles Chapman is president.

The Elliott-Blair Steel Company, Taylor and Mercer Streets, New Castle, Pa., has plans in progress for the construction of a new plant to cost approximately $250,000, including equipment. The works will comprise a number of one-story buildings, with installation to include two 12-inch rolling mills, and auxiliary apparatus. A large part of the plant will be given over to the manufacture of cold steel specialties, and all equipment will be electrically operated.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., has plans in progress for the construction of a one-story addition to its plant at Fairfield, Ala. The company is also planning for the remodeling of a portion of its works at Ensley, Ala. The projects are estimated to cost in excess of $100,000.

The Herzog Iron Works, East Seventh and Cypress Streets, St. Paul, Minn., has plans under way for the rebuilding of a portion of its plant, recently destroyed by fire, with loss estimated at close to $40,000, including equipment.

The St. Louis Wire & Iron Company, 926-28 Chouteau Street, St. Louis, Mo., has taken bids and will soon break ground for the construction of an addition to its plant for increased production. It will be two-story and basement, 50x140 feet, and is estimated to cost close to $40,000, including machinery. Theodore R. Fiesler is president.

The Penn Seaboard Steel Corporation, Philadelphia, Pa., is arranging for immediate increased operations at the plant of the Carpenter Steel Company, Reading, Pa., recently acquired. The works will be placed on a basis of close to 50 per cent of normal, with further advances expected at an early date.

The Memphis Wire & Iron Works, Memphis, Tenn., has preliminary plans under way for the construction of a one-story addition to its plant on Third Street, for general increase in capacity. It is estimated to cost about $50,000. McLean & Broadwell, Memphis, are architects. W. A. Haglin is president.

The Algoma Steel Company, Sault Ste. Marie, Ontario, has resumed operations of three blast furnaces at its plant, following a curtailment for a number of months. The company has secured a large order for steel rails, and this branch of the works will engage under maximum capacity with full working force.

The Open Hearth

William E. Hoblitzelle, vice president of the Duquesne Steel Foundry Company, Pittsburgh, will become president and general manager of the Smith & Davis Mfg. Company, St. Louis, in which he has acquired controlling interest, on August 15. Mr. Hoblitzelle was formerly general manager of the American Steel Foundries at St. Louis and general manager of the Commonwealth Steel Company, St. Louis. He resigned from the latter connection in 1918.

V V

R. D. Shields has been appointed assistant general manager of the Ohio Machine Tool Company, Kenton, Ohio. Mr. Shields will continue also as chief engineer, which position he formerly held.

V V

Arthur H. Quigley, for 12 years associated with the Kenosha, Wis., works of the American Brass Company, now owned by the Anaconda Copper Company, on July 1 was transferred to Toronto, Canada, as general manager of the Bronze-Brass-Copper Rolling Mills, Ltd., Toronto, an Anaconda interest. Mr. Quigley will have complete charge of development work as well as the general supervision of existing plants. He joined the Coe Brass Company at Torrington, Conn., in 1902 as an office employe, later becoming assistant to the president. In 1910 he was made office manager at Kenosha and in 1917 appointed assistant general manager under Clark S. Judd.

V V

N. R. Seidle was recently appointed works manager for the General Boilers Company, Waukegan, Ill.

V V

C. C. Clark has been named as successor to Kenneth C. Gardner who recently resigned as general sales manager, central district, Pressed Steel Car Company, to become vice president in charge of sales for the Greenville Steel Car Company, Greenville, Pa. Mr. Clark has been affiliated with the Pressed Steel Car Company for 20 years.

V V

Floyd H. Smith, formerly with the Pierce Arrow Motor Company, Buffalo as director of purchases, has become associated with the Simms Magneto Company, East Orange, N. J., as assistant general manager.

Silas H. Horn has become chief engineer for the Johnson Bronze Company, New Castle, Pa. Mr. Horn was formerly with the Brass & Bronze Company, Toledo, Ohio.

V V

Arthur A. Hammerschlag, president of Carnegie Institute of Technology, Pittsburgh, since 1903, has resigned and will become consulting engineer and advisor to corporations, with offices in Pittsburgh and New York.

V V

At a recent meeting of the board of directors of the Consolidated Steel & Iron Corporation, St. Louis, Mo., J. R. Finkelstein, president Hoosier Rolling Mill Company, Terre Haute, Ind., was elected president of the Consolidated Corporation. The other officers follow: F. J. Stuart, chairman of the board; Hugh Ferguson, first vice president; E. J. Schroeder, vice president and treasurer; M. C. Walsh, secretary.

V V

Charles H. McKnight, who has held the positions of president and chairman of the Carbon Steel Company, Pittsburgh, recently resigned from the former office at a meeting of the board of directors. C. F. Blue, Jr., who has been vice president, is Mr. McKnight's successor, and Frank C. Neale, president Kittanning Iron & Steel Mfg. Company, controlled by the Carbon Steel Company, and a director of the latter, has been made vice president in succession to Mr. Blue.

V V

F. G. Peterson, who has been managing superintendent of foundries, Bucyrus Company, South Milwaukee, Wis., for five years, has resigned to accept the position of general superintendent, Hercules Steel Casting Company, Milwaukee, succeeding Frank E. McIntyre, who has returned to the National Brake & Electric Company, Milwaukee. Operations were resumed by the Hercules Company on July 5 with a normal force after being idle for nearly a year.

V V

James A. McCrory has resigned as secretary and general manager of sales for the American Steel Company, Park Bldg., Pittsburgh, Pa., effective July 15. Mr. McCrory plans to engage in business on his own account after a vacation.

The Open Hearth

Edward Peterson has become associated with the Birdsboro Steel Foundry & Machine Company as chief engineer. He was formerly assistant chief engineer of the Treadwell Engineering Company of Easton, Pa., and prior to that was assistant to Mr. A. F. Backlin, chief engineer of the American Steel & Wire Company, Pittsburgh, Pa.

V V

Walter W. Leck resigned June 1 as general superintendent of the American Tube & Stamping Company, Bridgeport, Conn., to become general superintendent of the Scullin Steel Company, St. Louis. Mr. Leck was superintendent of rolling mills at the Steelton, Pa., plant of the Bethlehem Steel Corporation, prior to his connection with the American Tube & Stamping Company.

V V

Bertram D. Quarrie has resigned as general superintendent of blast furnaces and steel works of the American Steel & Wire Company to become general manager of the Otis Steel Company, Cleveland, a new position just created by that company.

V V

W. S. Stothoff, formerly works manager of the Hadfield-Penfield Steel Company, Bucyrus, Ohio, has resigned to engage in other business in the east. Mr. Stothoff is succeeded by R. O. Perrott, secretary of the company and resident manager of the Bucyrus plants, who has become manager of all the plants, the others being located in Mansfield and Willoughby, Ohio. Arthur Whitcraft has become manager of the company's steel foundry in Bucyrus.

V V

Frank L. Estep, junior partner of the firm of C. P Perin & S. M. Marshall, consulting engineers, New York, who recently sailed for Europe. plans to remain a few weeks in England in connection with engineering work for the Tinplate Company of India. Mr. Estep will supervise the completion of construction and the starting up of the plant in India. He will also represent his firm while in India in connection with work being done for the Tate Iron & Steel Company, the Mysore Distillation & Iron Works, the Indian Steel Wire Products Company. the Agricultural Implements Company, Ltd., and other enterprises.

V V

Frederick R. Sites was recently appointed private secretary of Judge Elbert H. Gary, chairman of the United States Steel Corporation, succeeding George K. Leet, who, after serving as private secretary for 11 years, was elected secretary of the Steel Corporation last April. Mr. Sites graduated from the Massachusetts Institute of Technology in 1899 and served for about a year in a minor capacity at the Central blast furnaces of the American Steel & Wire Company, Cleveland, and later in the Metallurgical Department of the Carnegie Steel Company, Homestead, Pa., for about a year. Nine years ago he became associated with the United States Steel Products Company and has just returned from Shanghai, China, where he has been manager in China for that company. During a part of the years 1918-19, Mr. Sites was treasurer of the Federal Shipbuilding Company, but returned to China when the export business became active after the war. Judge Gary became well acquainted with Mr. Sites while making a tour of the Far East six years ago. Mr. Leet, who has been serving as private secretary to Judge Gary, as well as secretary of the Steel Corporation since his election to the latter position, will now devote his entire time to the position of secretary of the Steel Corporation.

V V

S. F. Cox, formerly assistant to the consulting engineer of the Pittsburgh Plate Glass Company, has been made chief engineer of the Calorizing Company, Pittsburgh, the duties of which include management of the Wilkinsburg, Pa., plant of the company.

V V

Earl S. Murton was recently promoted to the position of assistant superintendent of the sheet department, Inland Steel Company, Indiana Harbor, Ind. Mr. Murton was formerly hot mill foreman of the plant. Prior to going to the Inland Company, Mr. Murton was with the Canton Sheet Steel Company, Canton, Ohio.

V V

James H. Walsh, who, for twenty years, was superintendent of the rolling department, South Chicago Works, Illinois Steel Company, has resigned to become assistant general superintendent of the Inland Steel Company, Indiana Harbor, Ind.

V V

Commander A. J. Chantry, Jr., U. S. N., has reported to the Charlestown Navy Yard, Boston, as production manager. He succeeds Commander W. B. Fogarty, who has been assigned to duty at Groton, Conn., as superintendent Electric Boat Company. Commander Chantry formerly was attached to the Philadelphia Navy Yard.

WITH THE EQUIPMENT MANUFACTURERS

"LITTLE GIANT" PIPE WRENCH PRESENTED TO THE TRADE

The "Little Giant" Pipe wrench, a new wrench with several interesting improvements has just been put on the market. The wrench has the "end opening" feature which is familia rto users of machinists' wrenches. Its application to pipe turning can readily be seen by a blance at Fig. 1.

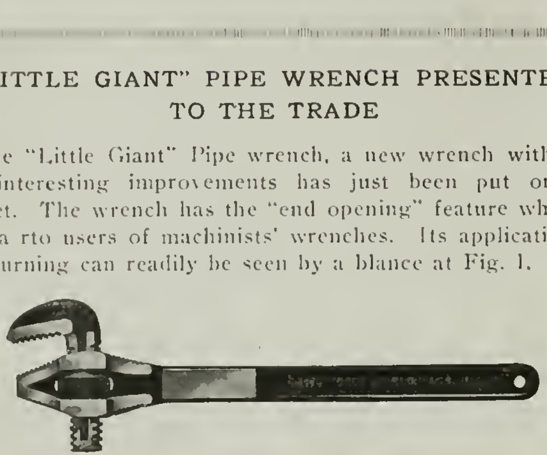

Fig. 1.

The advantage of the "Little Giant" wrench over the conventional style is the ease with which it can handle pipes in corners, close to walls, and similar confined places. The person using it can set it straight on the pipe as he would a pair of pliers, instead of having to fit the jaws on from the side.

The wrench has only three parts; a handle and jaw in one piece, which is drop forged and heat treated; a movable jaw, likewise drop forged and heat treated and a hardened steel nut. There are no springs, rivets, frame or pins, all these parts being eliminated. In spite of the absence of springs it takes hold and releases instantly at the option of the user.

The new wrench has been designed for maximum strength. The 14 in. size has repeatedly withstood stresses in excess of 4,700 inch pounds without slipping or bending. Readers familiar with government requirements will recall that the army and navy departments require a test of 2,800 inch pounds for a wrench of this size. Yet owing to the elimination of extra parts the "Little Giant," in spite of its extra strength weighs less than a Stillson type wrench of corresponding capacity. This is an advantage to users and dealers alike.

Another feature is the double set of teeth on the main jaw. The movable jaw can be engaged at the option of the operator with either of these sets of teeth with consequent lengthened life. On the large sizes, 14 in. and greater, two additional sets of teeth are provided, making four in all, and the movable jaw can be reversed to engage these additional sets of teeth, which are below the adjusting nut. This is very useful in connection with certain classes of work, besides practically quadrupling the life of the tool.

The new wrench is a product of the Greenfield Tap & Die Corporation, Greenfield, Mass. "Little Giant" is one of their trade marks, well known throughout the trade to all users of Screw Plates, Taps and Dies.

VAN DORN BUILDS A SPECIAL RADIAL ARM DRILL FOR MILLWRIGHT WORK

Realizing the great need in the industries for suitable tools especially adapted to the peculiar needs of millwrights and maintenance men, the Van Dorn Electric Tool Company of Cleveland, Ohio, has introduced the "Millwright Special," a Millwright's Radial Arm Drill to be attached to the wall or column for performing various jobs of a heavier stationary nature where rigidity and greater accuracy may be required.

Knowing the hard use and abuse to which portable electric tools are often subjected, the Millwright Drill is built strong and rugged in every part, completely encased in an aluminum housing also arranged for quick dissembling for greasing and cleaning.

The entire drill is well balanced, also very light and convenient to handle so that the operator can easily use it in most any position without experiencing extra exertion or fatigue.

The motor is of the universal type, for either A.C. or D.C. circuits. It is of the usual powerful and durable "Van Dorn" construction throughout, properly ventilated by an aluminum fan on the rotor shaft, and ball bearing equipped.

A special drill chuck permits the use of drills up to ⅝ in. diameter for drilling holes in iron and steel, while much larger wood bits can also be used.

The Millwright Radial Arm is of unique design with proper distribution of metal to give great strength and rigidity to withstand the heaviest drilling requirements, at the same time keeping the weight within limits that permit an easy swinging motion of the arm to allow quick location of the drill when in service; besides its convenient weight, permits the radial arm to be moved from one location to another when its services are required in different parts of the factory.

Two large pivot brackets bolted to the wall or column, support the entire arm. At the opposite end of the main arm casting is a second joint on which the short fore-arm swings. The outer bearings of the fore-arm form a support and guide for the drill bracket column. This forearm or second joint member gives great flexibility which permits accurate location of the drill.

The drill bracket or sliding member is raised and lowered by means of a long lever and toggle link mechanism. A secondary drill lifting arrangement is also provided in the form of a strong tension spring attached to the lower part of the drill bracket and hung from an extension rod above the fore-arm.

The Millwright Drill can be quickly attached to the Radial Arm by simply unscrewing one handle and bolting the drill to the adapter plate on the radial arm. Less than one minute is required to attach the drill from the arm

The entire scope of the arm with the drill attached covers a radius of 31½ inches from the drill center to wall pivots. The auxiliary forearm permits a secondary radius of 10½ inches to be swung for locating the drill.

The British Empire Steel Corporation, Montreal, Que., has preliminary plans under way for extensions and improvements in its plant, to cost in excess of $15,000,000. Plans are being prepared for new open hearth furnaces and new blooming mill, estimated to cost about $10,000,000. Extensive improvements will be made to two blast furnaces, including relining and general repairs. Other portions of the mill will be remodel and new machinery installed, bringing up the expenditure to about the point noted.

Some Pointers on By-Product Coke Oven Operations

THE RECOVERY OF BENZINE BY MEANS OF CHARCOAL

Several papers have been written during the last year on the Bayer process of recovering solvents like benzine, carbon disulphide, ethylene, etc., from solutions used in various important industries, as well as from coke oven gas, by means of "activated" charcoal. The Bayer Farbenfabriken of Leverkusen are activating charcoal by carbonizing wood in the presence of zinc chloride and other salts at 1,000 deg. C., and they claim thus to obtain a charcoal which, as regards benzine, is 20 times as active as ordinary charcoal. The regeneration of the charcoal is effected by means of dry steam at 180 deg. C. In the laboratory the Bayer method is already used to a considerable extent. Coke-oven works wash the gas with some oil to strip it of its benzine, and the technical substitution of activated charcoal for oil is so far only being tried. The two processes, washing with oil and adsorption by charcoal, are entirely different. The former process relies upon the solubility of benzine in the oil, the second on surface adsorption.

DESULPHURIZING OF COKE

A study of the desulphurization of coke was begun July 1 at the experiment station of the United States Bureau of Mines at Pittsburgh. This is a practical follow-up of the theoretical study of the oxidation of iron sulphate in the coke and subsequent removal of the free sulphur formed by this oxidation. Literature on this subject is being reviewed. Many patents were taken out in the years 1850 to 1870 and few since. Roasting and steaming were favorite methods. In this connection, methods for converting sulphur in coke into the FeS form are being sought. A process based on such method would hold back sulphur that might ordinarily be evolved, then this sulphur could later be removed by oxidation together with much additional sulphur. It seems that Fe_3O_4 mixed with coal being coked decreases the sulphur in solid solution. The work is being undertaken by Dr. A. R. Powell, physical organic chemist, and John H. Thompson, research fellow of the Carnegie Institute of Technology.

NEW RECORD IS MADE IN BY-PRODUCT COKE

To replace the deficit in beehive coke caused by the strike in the Connellsville region and other beehive coke districts, the by-product ovens are now producing at a rate above the average for 1920. The Geological Survey reports the total output of by-product coke in June was in round numbers 2,580,000 net tons, against a monthly average of 2,565,000 tons in 1920, the record year. The average output per working day was 86,000 net tons, an increase of 5 per cent over the May average. The month's production represented 70 per cent of the aggregate capacity of the ovens. Of the 71 plants in existence, 58 were active and 13 idle.

Because of the low production of beehive coke, 458,000 tons in June, against a monthly average of 1,748,000 tons in 1920, the total output of all coke was only 3,038,000 tons. This was 70.5 per cent of the monthly average of all coke in 1920.

COKE INVESTIGATIONS AT BIRMINGHAM

Investigations now being conducted by the Bureau of Mines at the Southern experiment station, Birmingham-Tuscaloosa, Ala., cover the physical properties of blast furnace coke, including physical tests, solubility of coke in carbon dioxide, and analyses of blast furnace hearth gas. In the study of the reactivity of coke with carbon dioxide, the effect of mesh of coke, temperature, rate of flow of carbon dioxide, and dilution with nitrogen has been further investigated. The work on hearth gas analyses at the plants of the Republic Company and the Tennessee Coal, Iron & Railroad Company has been completed. Completion of work at the plant of the Alabama Company at Gadsden, Ala., makes a total of six furnaces investigated in the Southern district.

SPECIFIC GRAVITY OF COKE

Experimental work is being conducted at the Pittsburgh, Pa., experiment station of the Bureau of Mines on the influence of fineness, medium, and time of boiling, in determining the true specific gravity of coke, which determination is used in calculating the amount of cell space or porosity of metallurgical coke.

MIXED COAL AND COKE FUEL FOR WATER GAS MANUFACTURE

Results obtained by W. J. Dunkley, gas engineer of the Bureau of Mines, in the course of experiments made at Ottawa, Ill., in the use of mixed coal and coke fuel for water gas manufacture, show that capacities up to 97 per cent of the rated capacity with good coke fuel can be obtained, using 70 per cent Illinois coal and 30 per cent coke from Kentucky coal, with 6 ft. gas sets operating up to 10 hours per day. The generator fuel consumption was about 33.5 pounds of mixed fuel per 1,000 cubic feet of gas made.

CARBONIZED LIGNITE FUEL

Experiments on the treatment of lignite, raw and carbonized, by the Trent process, are being made in North Dakota by W. W. Odell, fuel engineer of the United States Bureau of Mines. Construction of a vertical lignite carbonizing oven has been completed.

CARNEGIE TECH TO TEACH METALLURGY TO NAVAL OFFICERS

Carnegie Institute of Technology at Pittsburgh has been selected by the United States Naval Academy at Annapolis to give advanced courses in metallurgy to its graduate officers. Beginning next September, the Naval Academy will send two ordnance officers, graduates of the Acamedy, for a year's study in advanced metallurgy. Their studies will be confined principally to advanced metallurgy but will include some studies in electricity and physical chemistry. Other groups of graduate officers are assigned each year to various colleges or universities to study along specialized lines.

F. F. McIntosh, associate professor in metallurgy at Carnegie Tech, will supervise the studies of the naval officers. Lieutenants Gilbert C. Hoover and John H. Keefe have been assigned to take the work the next college year.

STUDYING STEEL SUITABLE FOR GAGES

Experimental work has been started by the Bureau of Standards in the study of the rate of or resistance to wear of steels when run in contact and without lubrication of any sort. The Amsler wear testing machine is being used for this investigation. The steels included in the preliminary studies form a series that has been submitted by the gage steel committee and which is being studied in detail to determine the suitability of the steels for gages. In gage work, the question of wear is of extreme importance.

TRADE NOTES

The Mesta Machine Company, Pittsburgh, Pa., announces the removal of their Chicago office from the McCormick Building to the Peoples Gas Building. Mr. C. J. Mesta, second vice president of the company, who has been in charge of the Chicago office for over a year, has returned to the home office in Pittsburgh to take charge of the sales department of the company. Mr. A. B. Neumann, mechanical engineer, has been appointed manager of the Chicago office. Mr. Neumann has been in the Chicago district for a number of years in the capacity of chief engineer and consulting engineer for several of the largest steel plants in that district.

Two large foreign contracts have just been closed by the Electric Furnace Company, Salem, Ohio. The first calls for an aluminum melting furnace for Germany, and the second for a set of automatic heat treating units for Japan. The United Aluminum Works, Lautewerke, Germany, has contracted for a 200-kw. tapping type electric furnace capable of holding 4,000 lbs. of aluminum. Mitsui & Company, New York City, has purchased, for shipment to Japan, a completely automatic set for heat treating forgings. The hardening furnace will be rated at 80 kw. and will contain five rows along which the forgings will advance.

The Economy Fuse & Mfg. Company of Chicago, Ill., announces the appointment of Charles H. Bluske as district sales manager of the Los Angeles office at 1304 Maltman Avenue.

The Pittsburgh sales office of the Economy Fuse & Mfg. Company has been moved from 2223 Farmers Bank Building to 1006 Peoples Bank Building at Fourth Avenue and Wood Street.

C. F. Ford, who for the past several years has been with the Chicago Pulley & Shafting Company, has recently joined the engineering sales forces of W. A. Jones Foundry & Machine Company, manufacturers of speed reducers and power transmitting machinery. In the near future Mr. Ford will be located in Minneapolis as manager of the Jones branch there.

The New Orleans Gas Light Company will install two U. G. I. vertical waste heat boilers and to that end have awarded contract for the installation to the U. G. I. Contracting Company of Philadelphia. These waste heat boilers will be attached to the carburetted water gas apparatus.

The Younglove Construction Company, United Bank Bldg., Sioux City, Ia., has been appointed representative of the Conveyors Corporation of America, 326 West Madison Street, Chicago, Ill., for the sale of American trolley carriers in northwestern Iowa and in South Dakota.

The Electric Furnace Construction Company, 908 Chestnut Street, Philadelphia, manufacturers of electric furnaces, "Electro" steam boilers, etc., report an increase in capital and the appointment of the following new officers: P. H. Falter, vice president and treasurer; Arthur G. Dickson, of Beitler & McCouch, Philadelphia, vice president and counsel; and of the following new directors: John Gilbert of Madeira, Hill & Company; Wm. A. Webb, president Empire Coal Mining Company; Dr. T. H. Weisenburg. Frank Hodson retains the presidency of the company.

The Torrington, Conn., Electric Company is making improvements to its gas plant in order to provide for increased manufacturing capacity and has placed its orders with the U. G. I. Contracting Company of Philadelphia.

The Iron & Steel Products Company has removed from 230 Fifth Avenue to 421 Wood Street, Pittsburgh, Pa. The company handles iron and steel products, specializing in relaying rails; also copper and brass, babbitt and solder, brake lining and packing.

TRADE PUBLICATIONS

The Hydraulic Society has gotten out a second edition of its pamphlet entitled "Trade Standards in the Pump Industry." This edition contains some additional tables and explanatory data, and also a revised list of members of the society. Copies may be secured from the members or the secretary, C. H. Rohrbach, 50 Church Street, New York, and if desired in quantities, will be supplied at cost of printing.

The Brown Instrument Company of Philadelphia, Pa., announce the publication of a new resistance thermometer catalog which explains the theory of resistance thermometry, the various types of instruments which are made, and the merits of each type, suggesting the really wonderful field which this instrument so ideally covers.

The American Engineering Company of Philadelphia has just issued a new publication entitled "The Rotary Ash Discharge." This booklet deals exclusively with a system of ash treatment and discharge which was originated and perfected by that company.

The Uehling Instrument Company of Paterson, N. J., have issued their four-page bulletin No. 113 describing their Pyro-porus filter for filtering flue gas samples to exclude soot and dirt.

The George T. Ladd Company of Pittsburgh, Pa., have issued a four-page folder, entitled "The World's Largest Power Boilers After Eighteen Months Operation." In it they tell of the performance records secured with their boilers at the River Rouge plant of the Ford Motor Company and reproduce four interesting steam flow charts. The boilers have operated for periods of four to seven months, each normally carrying 200 to 250 per cent rating, and at times for periods of 16 to 20 hours 300 to 350 per cent. At one time a rating as high as 425 per cent was reached. The last page of the pamphlet is devoted to a list of advantages of Ladd water tube boilers. Size 8½x11.

"Regulating Boiler Feed Water" is the title of a booklet just published by the Northern Equipment of Erie, Pa. It is divided into three general sections. The first is a reprint of an article from Power Plant Engineering emphasizing the importance of feed water regulation and discussing the requirements to be met. The second describes and illustrates the regulator made by this company. The third consists mainly of charts and descriptions of them showing how this regulator has met the requirements enumerated. Size 8¼x11. Twenty pages bound in heavy craft cover.

"Koerting Fuel Oil Burning Systems," is the title of a new catalog consisting of three bulletins bound in a stiff cover, recently issued by Schuette & Koerting Company, Philadelphia, Pa. The bulletins bear the titles, Mechanical Fuel Oil Burning Systems, Low and High Pressure Fuel Oil Burners, and Properties and Advantages of Fuel Oil. In them are discussed installations, operation and maintenance of oil burning equipment, the relative merit of mechanical spray oil burners, oil pumping outfits, the general requirements of steam boiler furnaces for burning oil, air for combustion, effects of carbon deposits and soot, etc. Size 8¼x11¼.

The London Steam Turbine Company of Troy, N. Y., successors to the Steam Motors Company, have issued their Bulletin No. 14 under date of May, 1922. In it they describe the advantages and features of their product. The bulletin is well printed on coated stock and contains a large number of excellent illustrations. Twenty-eight pages, size 8½x11.

Westinghouse Electric & Mfg. Co., East Pittsburgh. Circular 1579-B, containing general and technical data on Micarta, a non-metallic material for gear and pinion application, developed by the Westinghouse company. It is a laminated product of specially treated woven fabric of homogeneous structure and physical properties are claimed for it that make possible its substitution for untreated steel, cast iron, bronze and other materials used in gear manufacture. It is self-sustaining and may be machined with ordinary standard tools and equipment.

American Nickel Corporation, Clearfield, Pa. A 12-page bulletin, 8½ in. x 11 in., giving a resume of the properties and uses of pure nickel, shown by graphs and tabular comparisons.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., SEPTEMBER, 1922 No. 9

Association of Iron and Steel Engineers Annual Convention

The Sixteenth Annual Convention and the Fourth Annual Exposition of This Society Will Be Held in the Cleveland Public Hall, September 11 to 15.

THE Association of Iron and Steel Electrical Engineers will hold their annual exposition and convention at Cleveland, Ohio, September 11 to September 15, the official headquarters being the Statler Hotel, while the convention sessions will be held in the Cleveland Public Hall.

It is expected that a very large crowd of steel mill officials, such as general managers, general superintendents, department superintendents and engineers will be in attendance.

Aside from the technical sessions, the exposition offers an opportunity for these officials to become better acquainted with the latest advances in the electrical and mechanical arts. Practically all the manufacturers of electrical apparatus will have booths and demonstrate their appliances at the exposition.

The technical program, as arranged, is exceptional, as a glance at the list of subjects to be presented will readily prove:

"Improvement in Efficiency of Electric Power Supply."

"A Review of Steel Mill Electrification."

"Boiler Practices of 1922."

"Education" and "Safety."

"The Gas Engine as a Prime Mover for Power Generation."

"Steam Turbines."

"Judging Combustion From Gas Analysis."

"Electrification of the International Nickel Company's Works for Monel Metal."

"Some Considerations in the Electrification of the Steel Plant Railroad Yard."

"Power in the Iron and Steel Industry."

"Control-Motor-Lighting and Crane Standardization."

"Electric Furnaces."

"Electrical Developments in 1922."

"Investigation of Insulators for Steel Mill Service."

These papers have been prepared by the foremost engineers of the electrical industry, including such prominent persons as:

Dr. C. P. Steinmetz, B. G. Lamme, Wilfred Sykes, D. M. Petty and others.

It may be of interest to know something about how the Association of Iron and Steel Electrical Engineers originated and some of the history of the society since its inception.

Sixteen years ago, at a dinner attended by electrical engineers and electrical superintendents of the steel industry, one of the superintendents abruptly conceived the idea of perpetuating dinners of this nature, at which time discussions relative to the application of electricity to the steel industry would be presented, and, through the interchange of ideas of practical operation, a broader viewpoint of electrical application would be obtained, thus enabling the engineers and superintendents to obtain the advantage of each other's experiences in field operation.

The papers to be presented at the Association of Iron and Steel Electrical Engineers' convention, Cleveland, September 11 to 15, have been abstracted and will be found in the special section devoted to this convention, further back in this magazine. A directory to the booths, including the names of the various companies' representatives, will also be found there.

The suggestion provoked considerable discussion, and thus was brought about the formation of the Association of Iron and Steel Electrical Engineers.

This association has functioned regularly since that time, starting firstly with annual meetings, then sectional meetings being held in Pittsburgh, then sections were formed at Chicago, Cleveland, Philadelphia and Birmingham.

From the inception, this society devoted some of its time to the question of safety in steel mills. This question developed such proportions that it was thought best to form a separate organization to handle this matter in its entirety. From this came the formation, under the auspices of this association, what is known as the National Safety Council, of which we are justly proud. This accomplishment is particularly gratifying and has always been an inspiration towards the accomplishment of some of the big questions which have been brought up and solved since that time.

For fifteen years annual proceedings have been issued which contain the papers presented by steel mill engineers before this association. These proceedings are used internationally as references, especially so when new installations are contemplated; also for the performances of electrical apparatus installed in steel mills.

American electrical steel mill practices are being appreciated more and more in the foreign countries as each year the demand for literature from this association is increasing enormously, so much so that there are possibilities of the formation of a permanent section in some part of Europe.

In this country, some of the leading engineers in steel mills have written their expressions of appreciation for the valuable information contained in our issues, and it is a frequent request that some of these engineers have in asking for complete sets of these volumes.

It has been remarked at times that this organization tends to become narrow in confining its activities to one branch, that of the iron and steel industry.

Considerable deliberations were had on the subject of broadening these activities, but it was felt that in order to be of any value to its members, it had considerable to do to handle efficiently this one branch, in view of the fact that were time devoted to other branches, little would be accomplished in the way of furthering its original aims, that of the electrification of the iron and steel industry.

It was felt, however, that in order to completely cover the subject of electrification it would be necessary to enlist the support of the combustion and steam engineers of this industry.

From this idea was formed the Combustion Engineering Section of the society. While it has been organized only two years, its success was evident from the start,

Year after year questions concerning the industry are brought up, discussed and solved, which ultimately tends towards greater production at lower cost.

Likewise, conventions each year are attracting more and more attention, and the good accomplished at these annual meetings is evidenced by the increased number present at the sessions and exhibits and the number of engineers participating in the discussions of the various subjects presented.

Some of the leading scientists and engineers in America, as well as Europe, have taken an active interest in the convention being held this year, among them being Dr. C. P. Steinmetz and B. G. Lamme, in this country, and Sir Robert Hadfield of England.

The convention this year is attracting considerable interest and arousing enthusiasm to such an extent that the "Iron and Steel Exposition" this year will be one long to be remembered.

THE DISCOVERY OF MANGANESE STEEL

Hadfield's discovery of manganese steels as a result of research practically started the study of alloy steels. Before him, Mushet had, indeed, worked out empirically a self-hardening steel for metal-cutting tools, but it gave no such impetus to research in the field of useful metals. As a young man Hadfield started experimenting in his father's steel foundry to see if he could find a hard steel suitable for tram-car wheels. He melted his mixtures in crucibles and tested his products by the means then at hand—the file, chisel, forge, magnet, and hardening and tempering. These were enough to enable him when he first made an alloy coming within the definition of manganese steel to realize that he was dealing with a new metal.

Before his time, everyone who had tried the effect of increasing manganese in steel had found that the steel was made harder and less ductile with each increase, so that if 2.5 per cent were present the product was too hard and brittle to be of any use. The highest proportion ever added had been 3.5 per cent, which made the steel even more brittle. Naturally it was believed that more manganese would merely result in still greater weakness.

Hadfield, however, took nothing for granted, but tried everything and as a result found the new alloy which, when it contained about 13 per cent manganese, and was properly heat treated, had maximum combined properties of strength and toughness. He told his father, Robert Hadfield, and his superintendent, Mr. Mallaband, about his discovery. They were naturally skeptical and told him that he would better repeat his experiments. He did so with the same result and then they began to take notice.

Here was a high-carbon steel which in several ways was the opposite of what would be expected by any one familiar with iron. A magnet would not attract it, and when heated to a bright orange heat and cooled quickly, as by immersion in cold water, it was given extraordinary ductility. There were other less notable features, but these were enough to excite astonishment.

Naturally, the first attempts to adapt the new hard metal were for cutting purposes, particularly for metals, ,but experiments in that direction came to naught. The great field for this steel, resistance to abrasion, particularly by earthly materials such as rocks and ores, was not fairly recognized until ten years after the steel was first made.

The discovery, as the result of systematic research, of a metal having such unique properties as manganese steel, started other steel makers to see whether additional useful alloys could be found. As a result of these activities, which eventually extended throughout the civilized world, many alloy steels have been developed of exceeding importance, which have advanced materially the useful arts and particularly the conquest of distance on land, in the air and under the sea.

This discovery also argues strongly for research even without a definite object. Hadfield was searching for a hard steel for another purpose. He had no idea of finding a non-magnetic or water-toughening steel. So anyone has a chance of finding something new and useful in any systematic investigation or research which explores any unknown field of knowledge.

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*Contributed by Henry D. Hibbard, consulting engineer, Plainfield, N. J., to "Engineering Foundation."

Heat Balances of Blast Furnace and Steel Plants

Interesting Charts Showing Heat Balances for an Uneconomical Steel Plant, an Average Steel Plant, an Economical Steam Operated Steel Plant and an Ideally Operated Steel Plant Are Given.

By W. TRINKS

IN the production of iron and steel, fuel is only one item of expense, but it is by no means an inconsiderable one, although, in the United States, it is not nearly as large as the item of labor cost. The old saying, "The coal never goes to the iron ore, but the iron ore always goes to the coal," emphasizes the importance of fuel in the iron and steel industry. This old saying is no longer correct, because fuel economies in the production of iron and steel have brought the relative fuel consumption down to such an extent that a steel plant can now be located with justification anywhere between the iron ore mines and the coal mines.

In European steel plants, fuel economy has played a much bigger part than it has in American plants, and rightfully so, because on the European continent a ton of coal is worth as much as the daily wage of six labor-

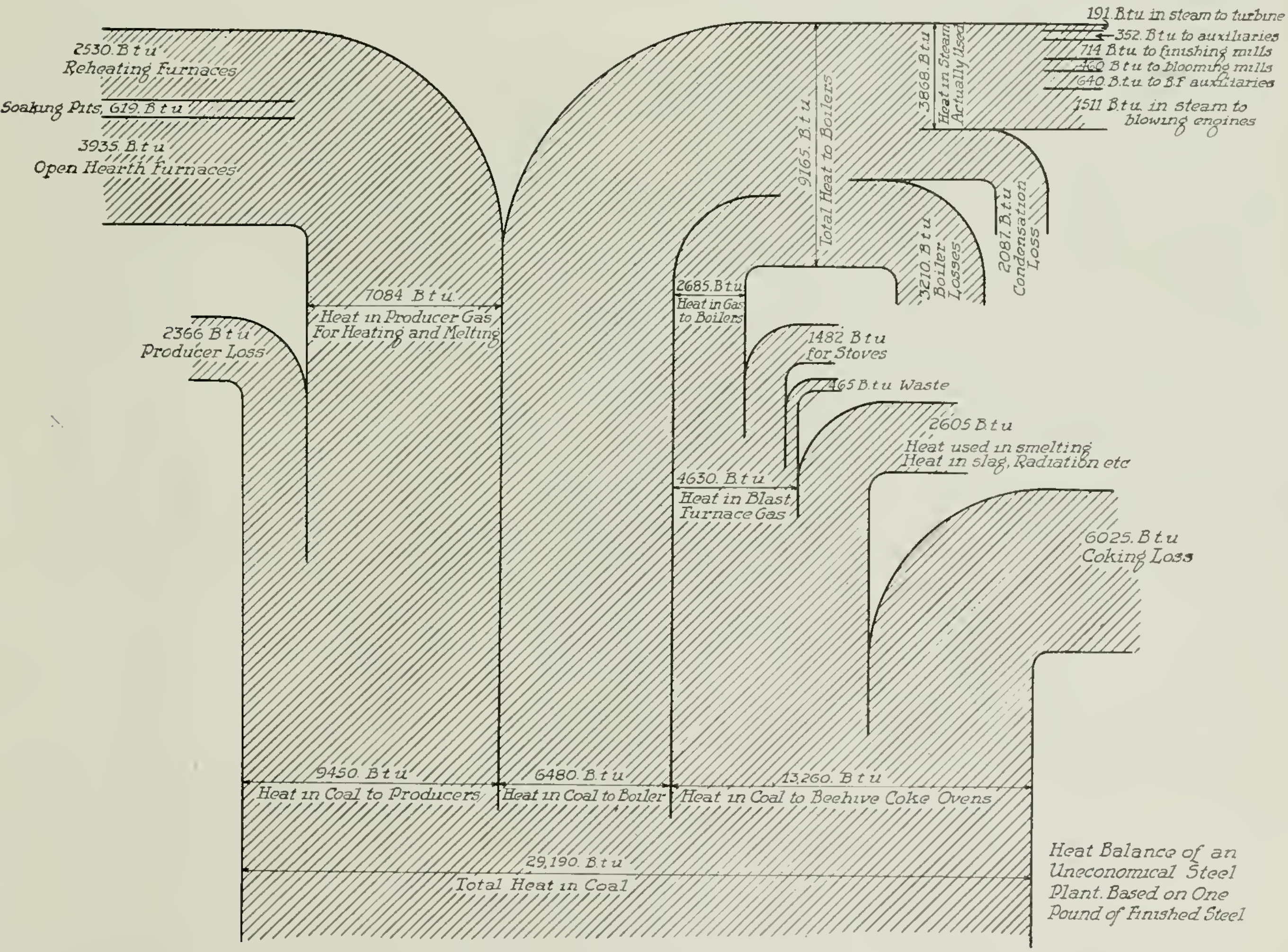

Fig. 1—Heat balance of an uneconomical steel plant based on one pound of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 2200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 7,000,000 Btu. required in open hearth per long ton of ingots produced; 1,100,000 Btu. in soaking pits per ton of ingots; 4,500,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, non-condensing. All auxiliaries steam operated. Steam blowing engines, non-condensing. Beehive coke ovens. (Note: All figures represent Btu. per lb. of finished steel.)

ers, whereas in the United States it is worth the daily wage of one laborer. If, to save a ton of coal per day, we must put on an extra laborer, we have saved nothing, as far as the final cost of steel is concerned; on the other hand, an European plant would, by the same process, save five-sixths of the cost of a ton of coal per day.

If we keep these facts in mind, we need not wonder at the different views which European and American steel works managers take of heat economy and of heat balances. The European manager studies the heat balance carefully, trying to find ways and means for saving a few more heat units. The American manager is apt to ask: What good is the heat balance after you have it? However, that happy frame of mind of the American steel plant manager cannot exist forever, partly because coal prices are rising steadily and partly because consideration of national resources demands better fuel economy.

From the standpoint of the desirability of fuel saving, it is unfortunate that its realization requires the in-

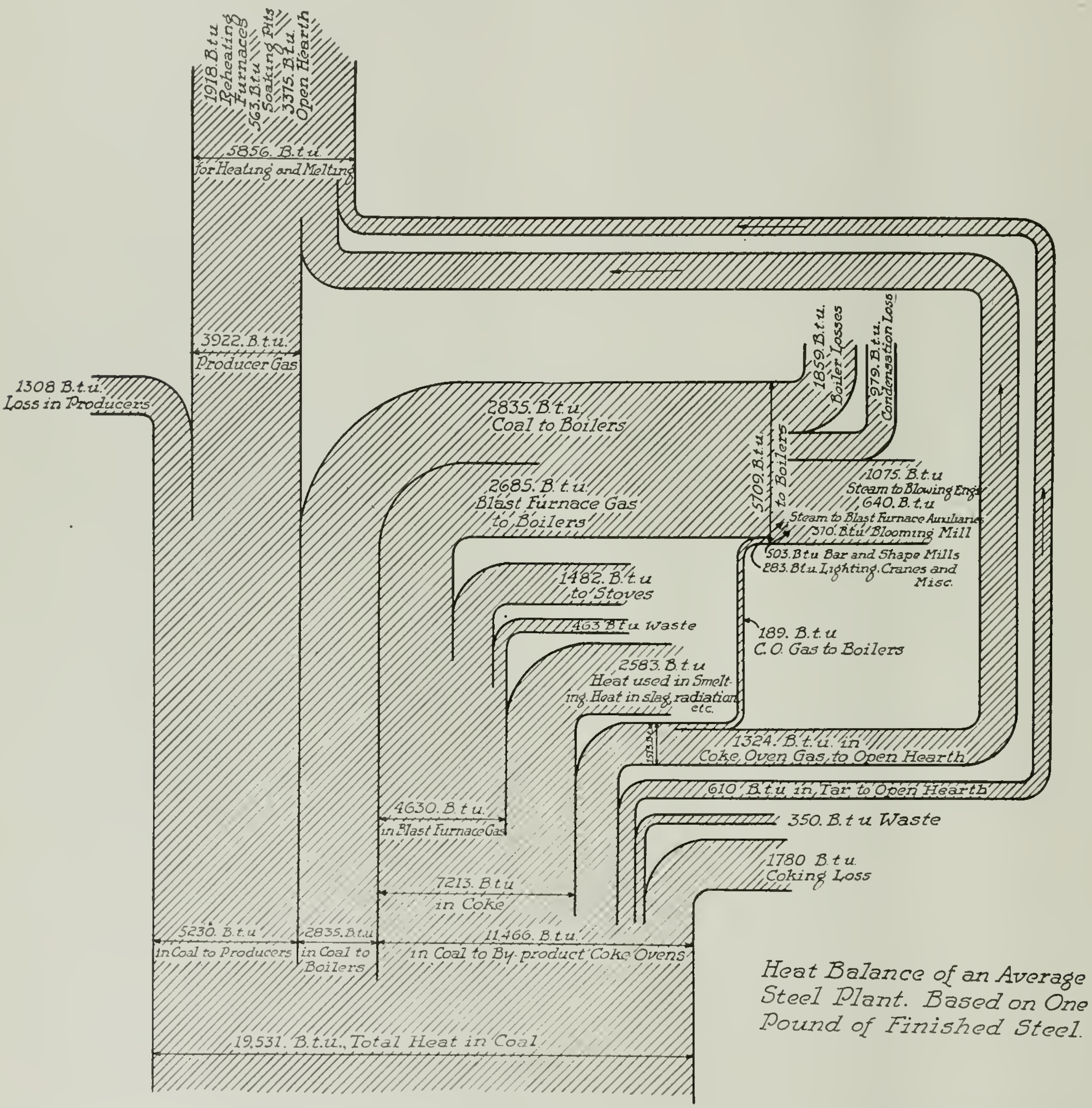
1918. B.t.u Reheating Furnaces
563. B.t.u Soaking Pits
3375. B.t.u. Open Hearth
5856. B.t.u. for Heating and Melting
3922. B.t.u. Producer Gas
1308 B.t.u. Loss in Producers
2835. B.t.u Coal to Boilers
2685. B.t.u Blast Furnace Gas to Boilers
1482. B.t.u to Stoves
463 B.t.u Waste
2583. B.t.u Heat used in Smelting. Heat in slag, radiation etc.
4630. B.t.u. in Blast Furnace Gas
7213. B.t.u in Coke
5709. B.t.u. to Boilers
1859. B.t.u. Boiler Losses
979. B.t.u. Condensation Loss
1075. B.t.u Steam to Blowing Engi
640. B.t.u Steam to Blast Furnace Auxiliaries
310. B.t.u Blooming Mill
503. B.t.u Bar and Shape Mills
283. B.t.u. Lighting, Cranes and Misc.
189. B.t.u C.O. Gas to Boilers
1575.B
1324. B.t.u. in Coke Oven Gas to Open Hearth
610 B.t.u in Tar to Open Hearth
350. B.t.u Waste
1780 B.t.u. Coking Loss
5230. B.t.u in Coal to Producers
2835. B.t.u in Coal to Boilers
11,466. B.t.u. in Coal to By-product Coke Ovens
19,531. B.t.u., Total Heat in Coal
Heat Balance of an Average Steel Plant. Based on One Pound of Finished Steel.

Fig. 2—Heat balance of an average steel plant. Based on one lb. of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 2200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 6,000,000 Btu. required in open hearth per long ton of ingots produced; 1,000,000 Btu. in soaking pits per ton of ingots; 3,800,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, 20 in. vacuum. Blast furnace auxiliaries steam operated, all other auxiliaries electrically operated. Electric power supplied by turbo-generator, steam blowing engines and turbo-blowers, 150 lbs. saturated steam, 20-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.)

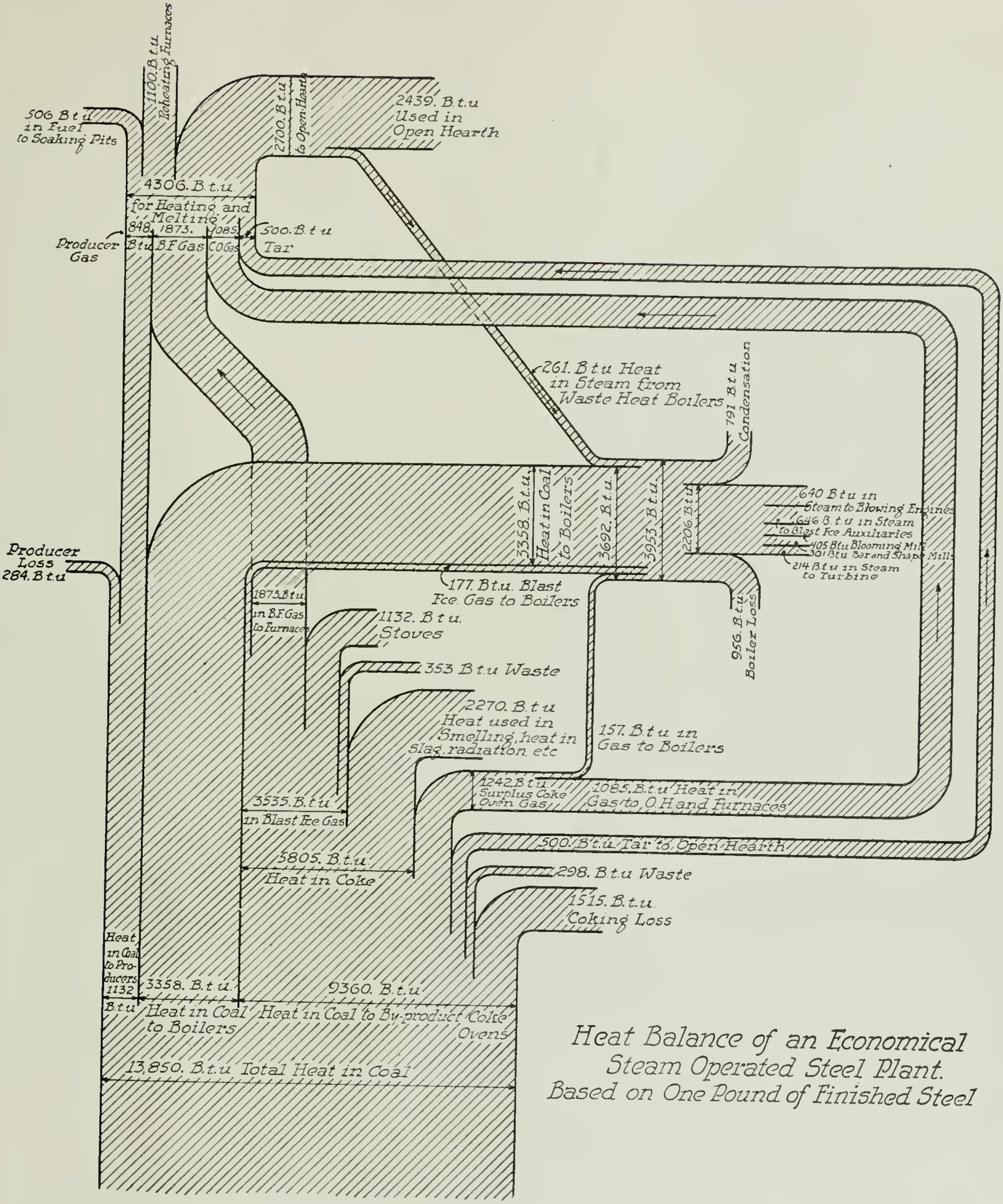
506 B.t.u in Fuel to Soaking Pits
1100. B.t.u Reheating Furnaces
2700. B.t.u to Open-Hearth
2439. B.t.u Used in Open Hearth
4306. B.t.u. for Heating and Melting
848. Btu Producer Gas
1873. BF Gas
1085. CO Gas
500. B.t.u Tar
261. B.t.u Heat in Steam from Waste Heat Boilers
791 B.t.u Condensation
3358. B.t.u. Heat in Coal to Boilers
3692. B.t.u
3953. B.t.u
2206. B.t.u
640 B.t.u in Steam to Blowing Engines
646 B.t.u in Steam to Blast Fce Auxiliaries
405 Btu Blooming Mill
301 Btu Bar and Shape Mills
214 B.t.u in Steam to Turbine
956. B.t.u. Boiler Loss
Producer Loss 284. B.t.u
177. B.t.u. Blast Fce. Gas to Boilers
1873 B.t.u in B.F. Gas to Furnaces
1132. B.t.u. Stoves
353 B.t.u Waste
2270. B.t.u Heat used in Smelting, heat in Slag, radiation, etc
157. B.t.u in Gas to Boilers
1242 B.t.u Surplus Coke Oven Gas
1085. B.t.u Heat in Gas to O.H and Furnaces
3535. B.t.u. in Blast Fce Gas
500. B.t.u. Tar to Open Hearth
3805. B.t.u. Heat in Coke
298. B.t.u Waste
1515. B.t.u. Coking Loss
Heat in Coal to Producers 1132 B.t.u
3358. B.t.u. Heat in Coal to Boilers
9360. B.t.u Heat in Coal to By-product Coke Ovens
13,850. B.t.u Total Heat in Coal
Heat Balance of an Economical Steam Operated Steel Plant. Based on One Pound of Finished Steel

Fig. 3—Heat balance of an economical steam operated steel plant. Based on one lb. of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product is rolled to 1-in. squares, one-half to 8-in. beams. 1.13 pounds of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per pound of finished product. 1,800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu. required in open hearth per long ton of ingots produced. 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas, blast furnace gas, and producer gas is used in reheating furnaces and in pits. Mills driven by economical steam engines, operating with steam at 200 lbs. pressure, 100 deg. superheat, 27-in. vacuum. Blowing engines steam driven, same conditions as above. Blast furnace auxiliaries steam operated, other auxiliaries electrically operated. Electric power supplied by turbo-generators, 200 lbs. steam pressure, 100 deg. superheat, 28-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.)

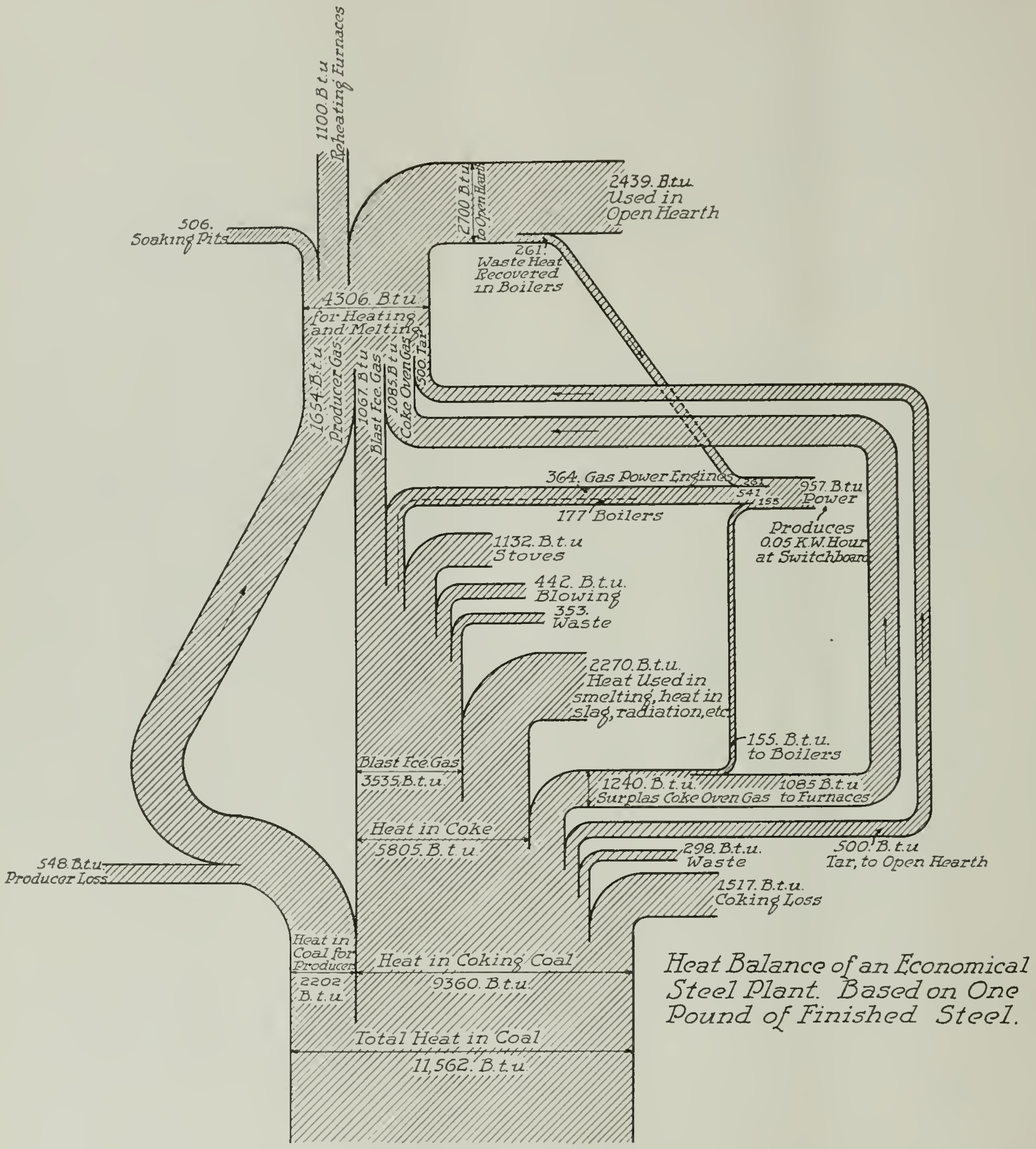

Fig. 4—Heat balance of an economical steam plant. Based on one lb. of finished steel. The heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 1800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu. required in open hearth per long ton of ingots produced; 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas and blast furnace gas is used for reheating furnaces and in pits. Power consumption includes blast furnace auxiliaries, rolling, cranes, lighting, shears, tables, etc. (Note: All figures represent Btu. per lb. of finished steel.)

vestment of considerable capital for fuel saving equipment. In the investigation of the problem, to what extent the installation of such equipment pays, several steps are required, namely, the determination of (1) how much can be saved, (2) what equipment is necessary for that purpose, and (3) what is the cost of that equipment? For a clear view of the relations affecting items (1) and (2), nothing is as helpful as a series of heat balances of various plants with different equipment and different modes of operation.

Figs. 1, 2, 3 and 4 are such heat balances. They are ideal heat balances and probably fit no one steel plant in existence. By that statement is meant that in one plant the blast furnace be more economical, and the open hearth less economical; in another plant, the pig to scrap ratio of the open hearth furnace will be different from the value upon which the ideal heat balances were based: in still another plant, heating furnace practice may differ from the assumptions, and so on. Nevertheless, the heat balances are representatives of different types of plants and are comparative. They were computed by Mr. J. D. Keller under the direction of the author.

Enough data are given with each set to judge the assumptions upon which each balance is based. Accordingly, very little comment is necessary. The following remarks may, however, be helpful. Fig. 1 shows the distribution of heat in a type of plant which was quite common 25 years ago, when coal floated down in barges on the Monongahela River at 65 cents per ton. The coking loss of the beehive ovens is included. On the basis of coal with a heating value of 13,000 Btu. per pound, a plant of that type used 2¼ pounds of coal per pound of finished steel. If sheet mills or wire mills are added, the additional reheating and the increased power consumption require additional coal.

Fig. 2 is the heat balance of what may be termed an average American steel plant. This term does not signify the average plant as it is being built today, but the average of those which are now in existence. The plant is assumed to have a by-product coking plant All mills are driven by steam engines, but most of the auxiliary equipment has been electrified. A rather poor vacuum has been assumed, because, with engines and with long lines of barometric condensers, the equipment is somewhat difficult to maintain and is frequently neglected. On the basis of 13,000 Btu./lb. of coal, the coal consumption per pound of finished steel equals 1½ pounds. This particular heat balance will probably be criticized, because every steel works engineer who goes over it will notice that his own plant differs in this or that from the conditions of the ideal average plant and will feel that some changes should have been made to adapt the heat balance to that plant in which he is interested

Fig. 3 was drawn for a type of plant of which there is probably none in existence today. It demonstrates what can be done in a plant in which excellent practice exists with regard to the blast furnace, the open hearth, the heating furnaces, and boilers, and in which steam engines operated at high pressure and with superheat are used for all the main drives and for blowing purposes, it being understood that all auxiliary equipment is electrically operated. The fuel consumption, under these conditions, comes down to 1.065 pounds of coal per pound of finished steel.

Fig. 4, finally, shows what can be done if a blast furnace and steel plant are equipped with the most economical equipment known and are operated in the most economical manner. The only fuel saving equipment which is not included in Fig. 4 is that of waste heat boilers on the gas engines. The plant is equipped with gas blowing engines and with gas-electric engines in a manner similar to the Gary works of the Illinois Steel Company, or to the Minnesota Steel Company in Duluth. Using again the value of 13,000 Btu./lb. of coal, we find that the coal consumption has been reduced to 0.89 pounds per pound of finished steel. Compared to the uneconomical plant, the fuel saving (figuring coal at $3 per net ton) equals $4.50 per gross ton of finished steel.

A few words should be said about the extent to which the heat balances apply to actual conditions. They do not take care of fuel for the yard engines, neither do they include fuel for auxiliary shops such as roll turning shops, pattern shop, machine shop, and foundry. They do not include Sunday losses due to bleeding of gas which cannot be used. Neither do they include coal for heating in the winter. These additional fuel requirements vary from plant to plant. They may tentatively be estimated to equal one-tenth pound of coal per pound of finished steel.

Heat balances of blast furnace and of steel plants form one of the subjects of instruction in Prof. Trinks' class in the "Mechanical Engineering of Steel Works," given in the night school at the Carnegie Institute of Technology during the coming winter. The course includes the mechanical engineering of the blast furnace, the mixer, the converter, the open hearth, heating furnaces, rolling mills, and forge plants. It does not include roll pass design.

The heat balances are worthy of some study. They show that in every case additional coal must be used besides that which is being delivered to the coke works. If a leaner ore is used, the coke consumption per ton of pig iron rises, and a point is reached where no additional coal is needed. That condition exists in most of the Southern plants in the United States. If the ore is still leaner, there may be an excess of heat available, particularly if more pig iron and less scrap are used in the open hearth than is indicated in the heat balance.

It is interesting to note that a plant which uses steam engines all the way through, with the exception of auxiliary equipment, can be made very economical, provided the rest of the equipment and operation is conductive to economy. If the power is generated in large steam turbines and is distributed electrically there will be an additional fuel saving, but it can only be slight, which fact will readily be seen from comparison of heat balances (3) and (4). It must be remembered that, in the latter case, both the blowing engines and the electrical engines are of the most economical type in existence.

The fuel economies which differentiate heat balance No. 4 from heat balance No. 1 are not confined to any one part of the works. They are the sum of heat economies in the blast furnace, in the mixer, in the open hearth furnace, in the heating furnaces, in the mill, and in the generation and use of power. In the introduction of fuel saving devices, steel works managers will, of course, first turn to those parts of their plant in which the greatest saving can be made with the least expenditure of money and effort.

Going back to the first paragraph of this article, concerning location and type of steel plants, we observe that, originally, blast furnaces and steel plants were located near the fuel. In the United States that location was principally the Pittsburgh district. In consequence, we have in that district a large number of plants with old, very uneconomical equipment. Coincident with engineering progress, fuel economies were developed, and new plants could move away from the fuel in the same measure in which such economies were introduced. Accordingly, we find the latest and best equipped plants not in the Pittsburgh district, but elsewhere. In time, the original steel plants in that district will doubtless be remodeled and be made more economical.

The Heat Treatment of Coke

The Effect the Improper Heat Treatment of Coke Has Upon Causing "Calico" Gas and Other Difficulties in the Blast Furnace.

By S. R. GREENE
Superintendent of Blast Furnaces, The Otis Steel Company

COKE quality has been greatly improved during last few years by the use of certain methods of heat treatment of the coal charge during the coking process within the coke oven.

Practically no constructive work has been done as to the proper heat treatment of the coke after it has been pushed out of the oven in a highly heated condition. Almost every other article produced in a highly heated condition is very carefully cooled or annealed to prevent loss or to secure excellence of finished quality.

The sudden chilling of any highly heated article results in certain peculiar physical, chemical or molecular conditions. Cooling slowly to a predetermined temperature and then quickly chilling causes other properties to develop peculiar to the temperature used. Cooling slowly to a complete chill exhibits still other phenomena. These various conditions have been thoroughly investigated and are made use of in the production of ceramic, glass, iron, steel, chemical products, etc.

How about coke? In general about the only controlling feature in the treatment of coke after it has been pushed out of the ovens in a highly heated condition, is that the customer objects to paying for water and the freight upon that water. The customer admits that the coke must be cooled to prevent burning away in the open air and generally agrees to pay for not over 3 per cent of water.

This is a fortunate condition as it requires the coke producer to limit the amount of water used in quenching in order to stay within the 3 per cent limit or else an enormous amount of coke would be ruined except at coke plants where there is a scarcity of water. The laws of Nature also tend to prevent the ruining of a great deal of coke due to the fact that when water is soused upon a body of hot coke that there is a great evolution of steam as the water penetrates the coke mass. This steam in escaping tends to prevent much water from penetrating deeply into the coke mass so that what water and steam does penetrate, cools the interior of the coke mass sufficiently to prevent burning away but fortunately leaves it hot enough to impart its excess heat back to the outer chilled over-quenched portions of the coke mass and by the annealing process thus set up a large part of ruined coke is restored to proper quality.

With the development of larger oven capacity came the requirement of larger quenching car capacity. Engineering difficulties necessitated the increase of car capacity by depth of coke volume instead of increased length of car. The deeper the coke mass the greater difficulty for the quenching water to penetrate deeply, thus accidentally less coke was ruined in the quenching process.

These conditions of customer's objections to paying for water and the deeper coke mass in the quenching car have prevented the production of an excessive proportion of chilled or over-quenched coke, yet it is probable that every oven pushed into a quenching car contains a considerable portion of ruined coke, not enough to cause a disastrous effect upon the blast furnace, yet enough to appreciably affect the coke consumption, as enough extra coke must be used to make up for the over-quenched part of the charge.

When over-quenched coke is charged into a blast furnace the first effect will be noticed at the stoves and boilers where the furnace gas is burning, when such coke has reached a depth of 15 to 20 feet below the stock line, the burning gas begins to show what is known as "calico" gas. This is a flame throughout which there are numerous small bright independent flames having a curly or wormlike appearance. As the charging of over-quenched coke continues the general flame of the burning gas is replaced by a white smokey gas or fume throughout which the small wormlike flames continue to burn, this is followed by a dense white smokey gas or fume that does not burn at all in the boiler fire boxes or furnaces, though it may burn out the top of the boiler stacks. The stoves show no evidence of this gas as burning, though it must burn high up in the combustion chamber because the stove gains heat while on gas.

In these later stages the furnace gas is found to contain high percentages of carbon monoxide with corresponding reduced carbon dioxide content.

Immense volumes of dense white gas are emitted from the boiler and stove stacks giving somewhat the appearance of a furnace that is excessively hot. The furnace itself becomes cold at the hearth and produces cold off grade iron.

The logical conclusion is that the over-quenched coke contains carbon of such a quality that it readily combines with the carbon dioxide gases at comparatively low temperatures near the top of the furnace. The reason that the furnace goes cold at the hearth is that not enough carbon gets down to the tuyeres to keep it hot, and the reason that not enough carbon gets down to the tuyeres is that a good deal of it has gone out the top of the furnace in form of carbon monoxide gas.

It is reasonable to expect that every coke plant using the regular accidental heat treatment of quenching in a quenching car, produces percentages of coke that when charged into the blast furnace quickly makes its escape from the furnace in form of carbon monoxide gas. While the percentage may be small, it is nevertheless lost for metallurgical purpose.

There is a prevailing idea that the percentage of moisture in coke determines whether the coke was or was not properly quenched.

The falsity of this idea was proven several years ago by experiments extending over a period of several months. The experiment consisted of pushing 16-inch ovens producing 6 to 8 tons into two quenching cars so that the effect of various depths of coke volume with regard to quenching could be noted. With a thin bed of coke about 18 inches deep along the discharge side of the cars, by passing the cars slowly under a quenching nozzle, quenching to blackness but still leaving the coke hot enough so that the moisture was driven off within a few minutes, over-quenched coke of less than 3 per cent moisture content was obtained. Under same conditions passing the cars quickly under nozzle and using the least amount of water that would prevent the coke from burning which left the coke at a low red heat, then allowing the coke to cool to blackness by atmospheric cooling and finally sousing to a complete chill, the resulting coke while it contained 12 to 14 per cent moisture showed no evidence of over-quenching when used in the blast furnace.

In ordinary practice the coke may be piled high in parts of the quenching car and low in other parts, very irregularity of quenching may be produced in one car with detriment to a portion of the coke.

During the period of these experiments over-quenched coke was deliberately produced and charged into the blast furnace with the results already described.

Though the preceding comments refer to by-product coke methods, the beehive producer frequently ships out coke that causes the production of "calico" gas and furnace difficulties, though in general using an entirely different method of quenching the coke.

Great improvement in quality or quantity of perfect product has been accomplished in the manufacture of many articles by using rational methods of heat treatment and there is no doubt that great improvement in metalurgical coke can be expected as soon as some intelligent heat treatment is devised in place of the present crude accidental methods forced upon the coke producer by commercial and engineering conditions.

Pyrophoric Flue Dust

Abstract of a Preliminary Report on a Study at Wissen to the Blast Furnace Committee of the German Eisenhiittenlente (Iron and Steel Institute).

By **DIPL. ING. J. W. GILLES**, Wissen
Stahl und Eisen, June 28, 1922

IT has been noticed for decades that the fine dust deposited in the gas passages of the stoves will glow on exposure to air; and this property now demands special attention because of the difficulties it offers in dry cleaning the gas by filtering. Whole chambers were burned out when changing tubes if they stood open too long. This difficulty has been overcome by quick work in changing tubes and keeping air away from the dust. The filtered gas is very clean and burns with a clear blue flame.

Whenever the top temperature is high, streams of sparks escape which consist mainly of reduced metal; and similar sparks show when cleaning the sacks nearest to the furnace, while the main bulk of the dust lies unburnt although it contains some 15 per cent of carbon. This sparking is a different matter from the quality of the dust in igniting itself. Pyrophoric dust is found even in the coarser material deposited close to the furnace. This dust, especially when the blast is low, will begin after some time, hours or days, to burn and this action is intensified by stirring, and is stronger the finer the dust. The filtered material contains the finest dust and shows the property most strongly. A cubic meter of the filtered dust weighs from 260 to 350 kilos against 1,500 kilos for the raw flue dust. Fineness is thus an important requirement of pyrophoric dust. When the Wissen flue dust is strongly compressed into cakes with a slaty cleavage, the flame of a Bunsen burner will ignite only so much of the cake as is in direct contact with the flame, the combustion not spreading further.

The extremely fine, loose dust is drawn from the filter tubes at about 80 deg. to 90 deg. into a collector vessel, often being taken from this vessel barely warm to the hand. There then follows a lively temperature increase which usually on stirring starts a glowing. The blue gray color of the dust in burning changes to reddish and an unpleasant suffocating vapor is given off. CO_2 and ammonia are present and a very fine white fume which has the characteristic evil odor of the dust, but which is very difficult to filter or precipitate out.

If the filtered dust is allowed to cool away from air it can later be exposed to the air without igniting itself. The flame of a match will ignite this dust and the glowing will then extend by zones throughout the whole mass.

Abstracted by S. L. Goodale, Professor of Metallurgy, School of Mines, University of Pittsburgh.

The ignition temperature of this dust is 167 deg. to 220 deg., the higher figure being for an old sample, fresh dust kindling more easily. The temperatures cannot be determined very exactly, but the difference shows that the dust loses on storage something of its self-igniting quality. The dust is sold as a potash fertilizer and sometimes will start burning slowly in the storage sheds when stirred up as in shipping.

The highest temperature reached in this combustion is 600 deg. A bomb calorimeter test showed 473 calories evolved per gram of dust, but this figure is probably high, as the oxidation in the bomb goes to a higher stage than in air.

If the filtered dust is heated in illuminating gas or hydrogen the white vapor and bad smell come off, and if the heating were enough, the dust glows on exposure to air. Some hours heating above 200 deg. in CO_2 causes slow oxidation and changes the color to red. The pyrophoric character disappears.

From several tables of analyses of various flue dusts gathered for comparison, some being pyrophoric and others not, no conclusion could be reached as to which constituent caused the pyrophoricity.

Some 3 per cent of iron is present in the Wissen flue dust, but no magnetic particles occur, and none can be identified as metal. The sudden burning of a dust at the Nennkirchnir works ordinarily not pyrophoric was due to metallic iron, but there some 24 per cent was present. Further experiments showed that neither zinc nor carbon was a probable cause of self-ignition.

The managnese content at Wissen and at some other places is remarkably high and Erdmann states that finely divided MnO will oxidize in air. The Mn is present in part in the flue dust as free MnO, a part of which on burning is oxidized to a higher oxide. MnO produced by heating $MnCO_3$ in CO_2 and in illuminating gas showed strongly pyrophoric, the ignition temperature in both cases being 182 deg. It may be concluded therefore that free MnO is present in the dust and is the cause of the pyrophoric property. At the Burbacher works the dust was especially pyrophoric when gases from a ferromanganese furnace were added to gas from a furnace on basic Bessemer iron. Analysis of some recent dust from Wissen that was but little pyrophoric showed less Mn and less S as sulfid, and more iron than in strongly pyrophoric dust. It has been observed by the gas cleaners that with higher gas pressures the dust is less pyrophoric. Other dust samples high in manganese but not pyrophoric are shown not to contain free MnO, but to become pyrophoric when heated to 500 deg. in a reducing gas, the ignition temperature then being 260 deg. to 270 deg.

The Wissen dust shows a high sulfid S content, which on burning goes over to sulphate, but the ignition temperature of dry fine iron sulfid is 350 deg. to 370 deg.

The conclusion is reached that MnO is the chief cause of the pyrophoric quality of the Wissen dust; also that while the fresh warm dust will ignite spontaneously the dust cooled away from air will not ignite until heated to 180 deg. because of superficial oxidation. Other oxidizable bodies strengthen the phenomenon when once started by their evolution of heat. Also it is possible that some constituents of the dust act catalytically to strengthen the pyrophoric quality of MnO.

Director Harr of Hordee reported, in discussing Dr. Gilles' paper, that their chief chemist had carried on investigations which made it seem probable that MnO, or still more likely FeO, was the real cause of the spontaneous combustion. Certain samples of flue dust were treated so as to remove all other possible pyrophoric constituents except the FeO and were then found to have just the same pyrophoric qualities as before the treatment.

THE MARCONNET FUSED-ASH GAS PRODUCER FOR GAS-COKE SMALLS.

A review is given of a paper recently contributed to the annual conference of the Societe de l'Industrie du Gaz en France, by M. G. Riviere.

It would appear that to fuse the ash, high temperatures are essential, and application has been made by a French company of the ideas advocated by M. Marconnet.

The chargers are at the top, the upper part being of refractory brickwork, whilst the lower presents water-jackets, which allow a series of orifices for cold air blast, for poking-up, and for steaming. There is also an arrangement for knocking the mass together. The gas produced emerges at the top, and is freed from dust by a baffler.

The various cokes used varied in their percentage of ash, and particulars are given of the results obtained, which were perfectly satisfactory.

Gas-coke smalls can be gasified by a cold blast, scurfing becomes unnecessary, and the fused ash granulates beautifully when falling into water. The thermic efficiency is good ,the latent heat of the gas being 71.4 per cent, and its sensible heat 12 per cent of the heating value of the coke used. Coke-smalls are enabled to be used up in the gas works, instead of the larger-sized coke usually employed in the producers.

CONSTRUCTION PROPOSALS FOR THOMAS CONVERTER

Bruno Versen, in a recent issue of Stahl und Eisen, has the following to say regarding the Thomas converter:

A great defect in the Thomas process is the amount of losses; these it has been proposed to avoid by reducing the period under blast. The losses are due, generally, to the fact that the convertors are too small for what they are supposed to hold, and also to excessive blast pressure. In the effort to equate the necessary amount of blast to meet the continually increased charges, the pressure has been raised to 2½ atmospheres and mire, instead if enlarging the cross-section of the convertor; the amount of blast is then increased in such a way as to obtain steady working. The whole cross-section should bear a certain minimum proportion of the surface under blast, represented by the nozzles at the bottom; this minimum proportion should be 3½.

The blast pressure should be calculated, commencing with the indispensable volume required, and the total nozzle section necessary to deal with same, not forgetting the considerable resistance loss, which is estimated to be not under 60 per cent.

In estimating pressure, one has to consider the charge of iron and slag, as well as a certain surplus pressure, for which, to ensure the escape of the blast, and also a working reserve, allowance must be made.

New Plate Mill For Granite City Plant

The National Enameling & Stamping Company Has Ordered from the United Engineering & Foundry Company Modern Plate Mill Equipment.

By M. E. GRIFFIN

THE National Enameling & Stamping Company located at Granite City, near St. Louis, Mo., have recently placed an order with the United Engineering & Foundry Company for complete new plate mill equipment. The plans for this new plate mill are of more than usual interest because of the fact that many important improvements are incorporated in its design.

The company has at present a two-high engine-driven plate mill. To the approach table of this mill they are adding a furnace table 43 ft. 9 in. long with 12 x 41 in. rollers driven by a 40-hp. motor. The slab, or ingot, is discharged from a continuous furnace to this table from which it is fed to the two-high mill where it is roughed into slabs of a thickness that depends upon the thickness of the finished plate.

Part of the old leveller approach table is to be removed and in its place, the new three-high plate mill and mill tables will be located.

The top and bottom rolls of this mill are 34 in. diameter, the middle roll 22 in. diameter and the face of all three is 100 in. Plates from No. 10 gauge to 1¼ in. thickness will be rolled. Frequent roll dressing is required in order to keep a smooth surface on the finished plate and, to redress the rolls, they are removed from the mill and re-turned and ground.

A new design middle roll operating rig is being furnished, the main feature of which is the ease with which roll changing is accomplished. In this design, the arms carrying the middle roll, and hydraulically operated, are not removed from the mill but are disengaged from the roll and rocked back from the mill towards the table, leaving the entire window opening unobstructed.

The top roll is balanced by means of a hydraulic cylinder placed above and connected to the balance beam and roll bearings by easily removable hanger bars.

A 60-hp. motor is required for the screw down

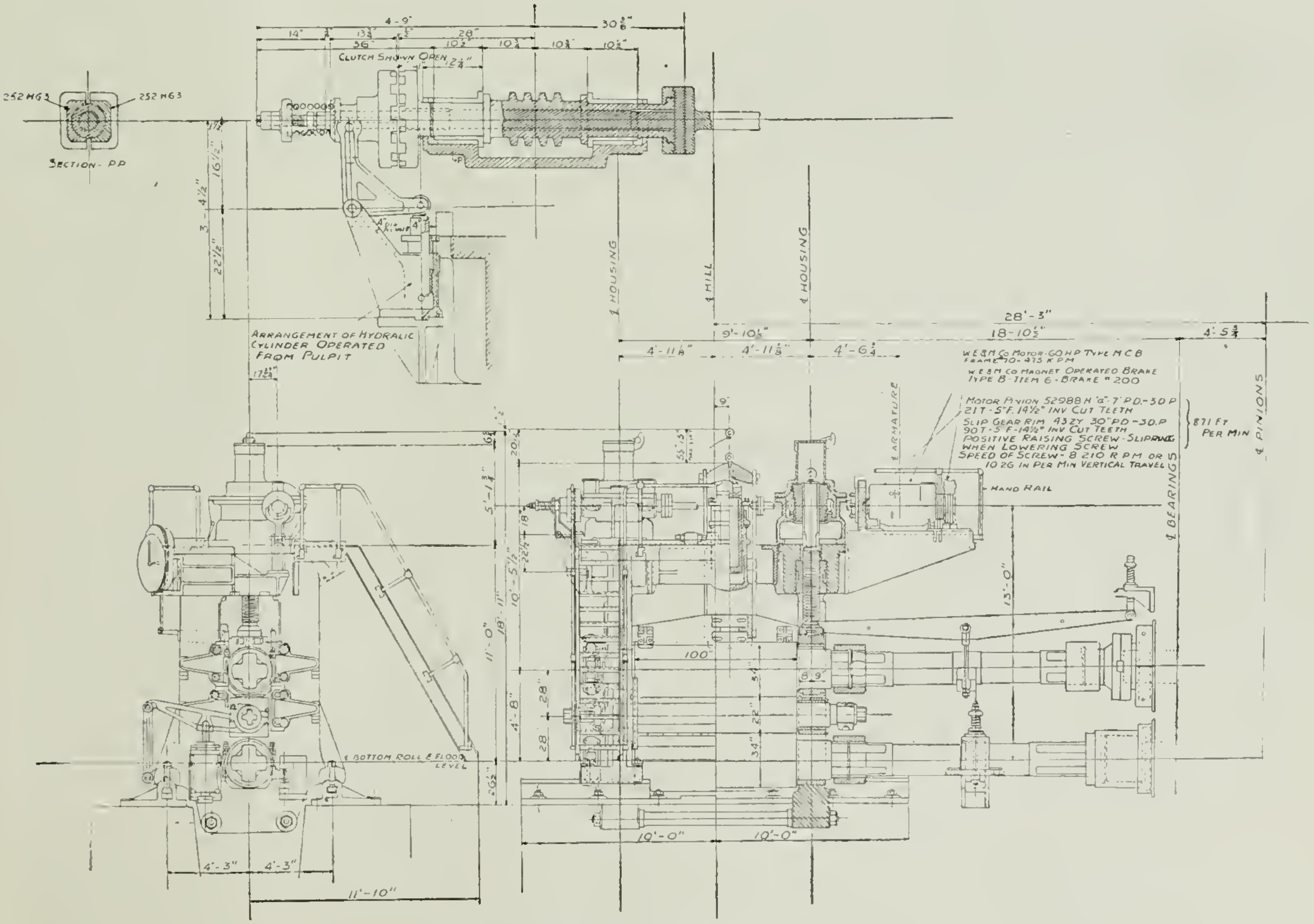
252 HG3
252 HG3
SECTION - PP
CLUTCH SHOWN OPEN
ARRANGEMENT OF HYDRALIC CYLINDER OPERATED FROM PULPIT
℄ HOUSING
℄ MILL
℄ HOUSING
℄ ARMATURE
W E & M Co MOTOR - 60 HP TYPE MCB FRAME 70 - 475 RPM
W E & M Co MAGNET OPERATED BRAKE TYPE 8 - ITEM 6 - BRAKE # 200
MOTOR PINION 52988 H 'a' - 7" P.D. - 30 P 21 T - 5" F. 14½" INV CUT TEETH
SLIP GEAR RIM 4327 30" P.D - 30 P 90 T - 5" F - 14½" INV CUT TEETH
POSITIVE RAISING SCREW - SLIPPING WHEN LOWERING SCREW
SPEED OF SCREW - 8 210 RPM OR 10 26 IN PER MIN VERTICAL TRAVEL
871 FT PER MIN
HAND RAIL
℄ BEARINGS
℄ PINIONS
℄ BOTTOM ROLL & FLOOR LEVEL
4-9"
30⅝"
14"
56"
28"
2¼"
16½"
22½"
3'-4½"
28'-3"
18'-10½"
4'-5¾"
9'-10½"
4'-11⅛"
4'-11⅛"
4'-6¾"
100"
13'-0"
11'-0"
18'-11"
10'-5½"
5'-1¾"
4'-8"
34"
22"
28
10'-0"
10'-0"
4'-3"
4'-3"
11'-10"

Fig. 1—Plan of the new plate mill.

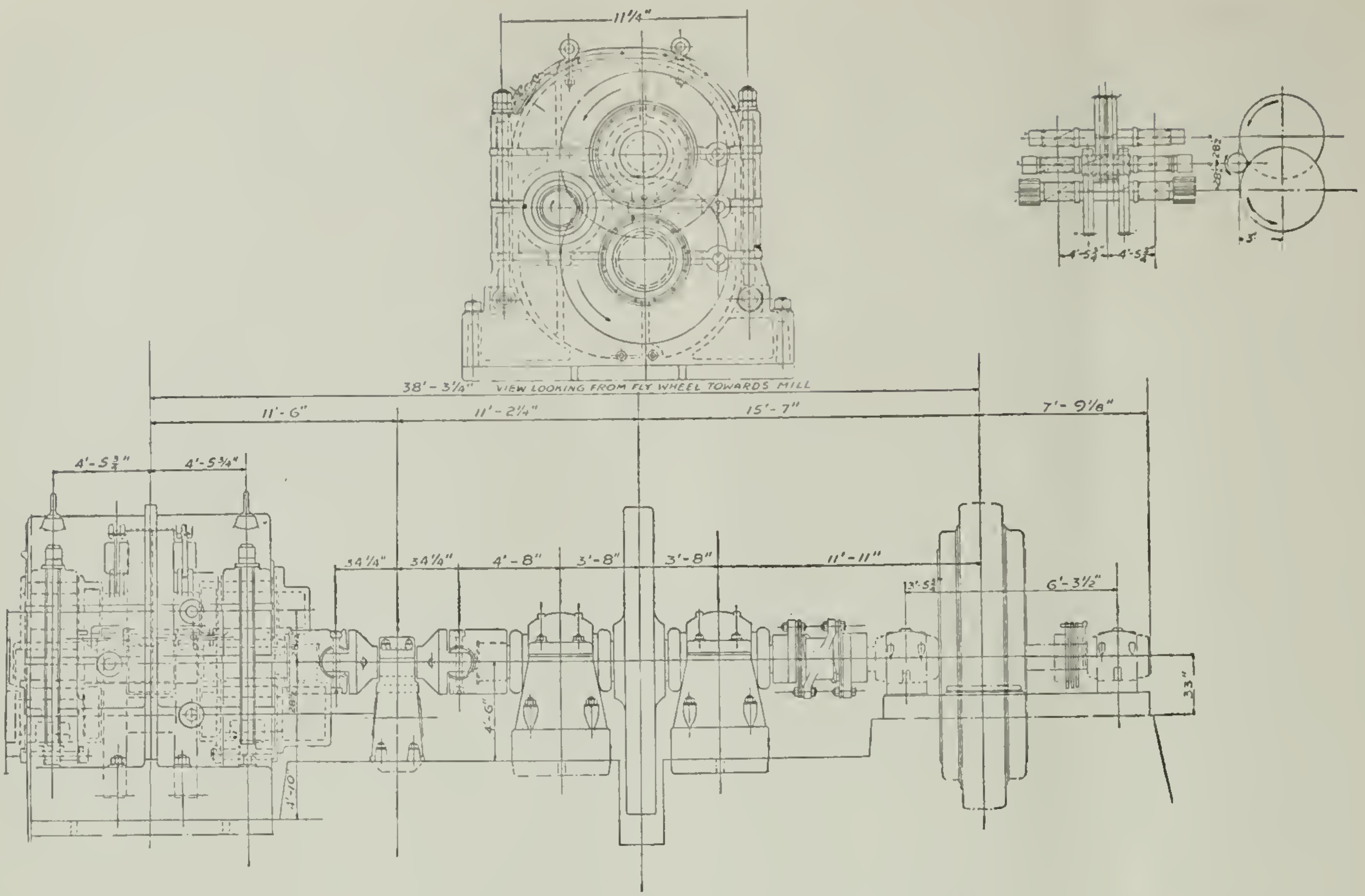

Fig. 2—General arrangement of pinion stands and flywheel.

which is of the worm and worm wheel type. In order to keep the space between the entire length of the rolls the same so as to insure uniform thickness of plate, a clutch is used in the worm shaft so that one screw may be operated independently of the other. This adjustment must be close and be made frequently. A hydraulic cylinder permits operation of this clutch by simply opening a valve placed in the pulpit or other convenient location.

An 8 in. accumulator of about 5 foot stroke to maintain 500 pounds per square inch water pressure is furnished for the operation of the cylinders.

The pinions are cut with double helical teeth and arranged so that 4½ to 1 speed reduction is attained, eliminating a separate gear reduction set, and therefore considerably reducing the floor space.

The heavy flywheel provided to take care of the main peak load is cast steel of the umbrella or mushroom type and a Tod type universal spindle connects it to the main driving pinion. The flywheel is connected to the motor by a flexible coupling. The motor is 3000-hp., 2200-volt, 3-phase, induction type with a speed of 235 rpm., giving a mill speed of 52 rpm.

In a three-high plate mill the slab is passed first between the bottom and middle rolls, with the middle roll held up against the top roll by the aforementioned operating rig; the middle roll is then lowered and the piece raised by the table and passed back between the top and middle rolls, the middle roll being in contact with the lower roll. The middle roll is then raised, the tables lowered and another lower pass made and this is repeated until the plate is of desired thickness. To accomplish this raising and lowering of piece, tilting tables are used. The old type of cast table girder has been discarded and a rolled steel slab, machined to an I section, used. Each of the tilting tables is 27 ft. 6 in. long with 17 disc type rollers driven by an 80-hp. motor. The mitre gears are forged steel with cut teeth. Contrary to the older designs, there is but one line shaft and one motor on each table. The tilting tables are roller bearing equipped.

These tables are operated by our patented air hydraulic system. The ends farthest from the mill are supported on massive rocker stands or trunions while the mill end is carried on levers mounted on shafts. By means of hydraulic cylinders operating through levers on the outer ends of these shafts and connected by a link, the tables are balanced.

These cylinders are piped to a vertical tank partially filled with water. The upper end of this tank carries air at a sufficient pressure to balance the tables in mid-position. Two series connected 100 hp. motors geared to the lever mechanism serves to operate the tables. When lowered, the water is forced from the cylinders into the tank, further compressing the air. This results in an over-balance, cushioning the tables at the bottom of their down stroke and relieving the motors of part of their work in starting the up-stroke. As they rise the pressure lowers, decelerating them towards the end of the stroke and leaving them underbalanced. This underbalance operates to help start the tables downward.

Two plate shears are also to be installed. One is a No. 6 108 in. with a capacity to cut 1⅛ in. plate, and the other a No. 4 156 in. for cutting 9/16 in. plate. These shears are equipped with oil gags, but are so arranged that magnetic holddowns may be added.

Special Drive Designed For Plate Mill

Main Motor Drive for New 100-in. 3-High Plate Mill for the National Stamping & Enameling Company

By F. D. EGAN*

THE National Stamping & Enameling Company has a 2-high 90-in. reversing plate mill, engine driven, and in order to increase the output as well as the finish of the plate and to be able to roll plate to thinner gauge, they are installing a 3-high 100-in. Lauth type finishing stand to be located 75 ft. beyond their present mill. The arrangement and method of rolling will be similar to that employed at the 84-in. tandem plate mill of the Brier Hill Steel Company, roughing the ingot or slab to width and suitable thickness for entering the finishing stand in the 2-high roughing mill and finishing to proper gauge in the Brier Hill Steel Company's 84-in. tandem plate mill, which holds records for the number of slabs rolled per hour, per day and per month, as well as thinness of gauge for the width of plate rolled, having rolled 220 slabs per hour, 1,659 slabs in 12 hours and 3,270 slabs in 24 hours.

The main motor for driving the 100-in. 3-high stand of this tandem plate mill will be especially designed for a drive of this character, as the motor will be subjected to very severe service. To meet this condition, the pedestal bearings will be designed low and very rugged. The motor is rated 3,000 hp., 40 deg. C., 2,200 volt, 3 phase, 60 cycle, 236 rpm., and will develop a starting and pull out torque of 2½ times full load torque corresponding to 7,500 synchronous hp. It is of the wound rotor induction type and is shown in Fig. 1.

From an examination of the photograph showing the motor it will be noted that it is designed with the supporting feet near the horizontal center of the plane and cast integral with the frame. The feet have screws and liners for horizontal and vertical adjustment so that the stator can be moved by fine increments in any direction for the purpose of lining up the air gap, and to compensate for any wear of the bearings. The laminations are dove-tailed into ribs in the frame casting and are clamped between heavy end plates with fingers for supporting the teeth. The slots are of the straight open type and the winding is composed of duplicate coils completely formed and insulated before being placed in the slots. Before the coils are placed in position the slots are lined with fish paper cells which prevent the coil insulation from coming into direct contact with the iron, thus protecting it during the process of assembly. To seal all the joints in the insulation and guard against metallic dust prevalent in steel mills, the entire winding receives several treating processes with special insulating compounds. In order to withstand mechanical vibration and surges due to switching and extreme fluctuations in load, the coils are strongly braced. The slot portions of the coils are held in place by hard fibre wedges driven into grooves in the sides of the teeth, and the coil ends are braced by lacing each coil to an insulated steel ring supported by the stator frame.

The rotor is to take the brunt of the shocks and vibration transmitted from the mill pinions. It also must be capable of withstanding the severe unbalancing strains set up when the motor is "plugged," i. e., reversing from full speed in one direction to make a quick stop. For this reason the rotor is built up on a rugged double arm cast steel spider with the laminations dove-tailed into the spider and clamped between heavy end plates with fingers for supporting the teeth. A special feature found in Westinghouse rotor slot and coil construction is the use of form wound coils similar to those used in straight open slot construction. The rotor coils are made up of two straps side by side, each strap being formed to exact shape and completely insulated before assembly. The use of partially closed slots gives a high power factor without the disadvantage of a small mechanical air gap, and at the same time permits the use of completly formed and insulated coils. The opening at the top of each slot is sufficient to allow one fully insulated strap to be dropped in one at a time and there is no forming and insulating operation performed after the coils are put into the slots. This method of assembly gives excellent insurance that a good job is being done at the factory and facilitates the removal of coils for repairs in case of accident.

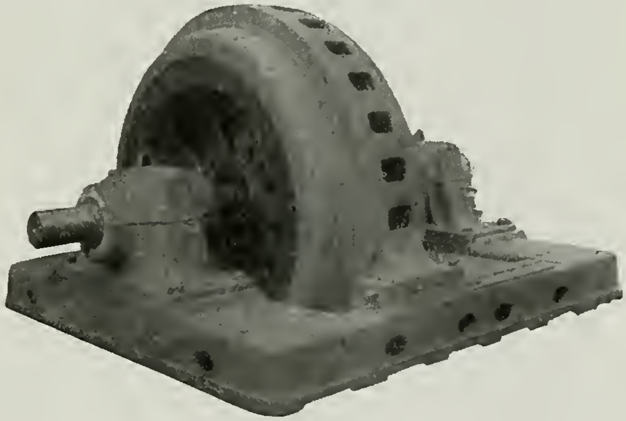
Fig. 1—View of motor.

A motor of this size has a wide core and the question of proper ventilation was given special attention. The core is provided with radial air ducts placed at frequent intervals through which the cooling air is forced by the centrifugal action of the rotor. These air ducts have been made liberal in size so as not to become clogged with mill dust and to facilitate blowing out when cleaning the motor. In addition the rotor carries a fan on each side and the end plates bolted to the sides of the frame are shaped to guide the air supplied by these fans around the coil ends to the back of the stator core where exhaust openings are provided in the frame. The entire system of ventilation is designed to bring the cooling air in direct contact with all parts of the machine where heat is generated, thereby preventing "hot spots."

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*General Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

The pedestals are ruggedly built with low bearing centers in order to give strength and rigidity necessary to take up the shocks and vibrations from the mill. The bearings are designed with high grade babbitt lined shells and are designed to operate with oil ring lubrication alone. As an additional safety measure, however, both bearings are arranged for gravity oil lubrication. Each one is split horizontally and so designed that the top half can be readily removed for examination of the journal, and the bottom half rotated out by relieving the bearing of the shaft weight. The bearings are made dust proof by means of felt packing at the oil hole covers and around the shaft.

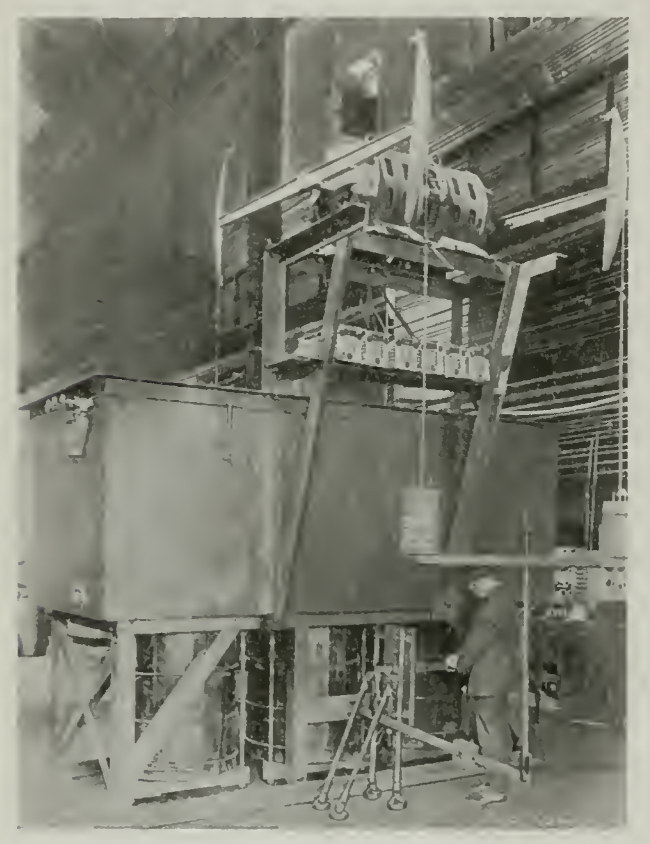


Fig. 2—Liquid slip regulator.

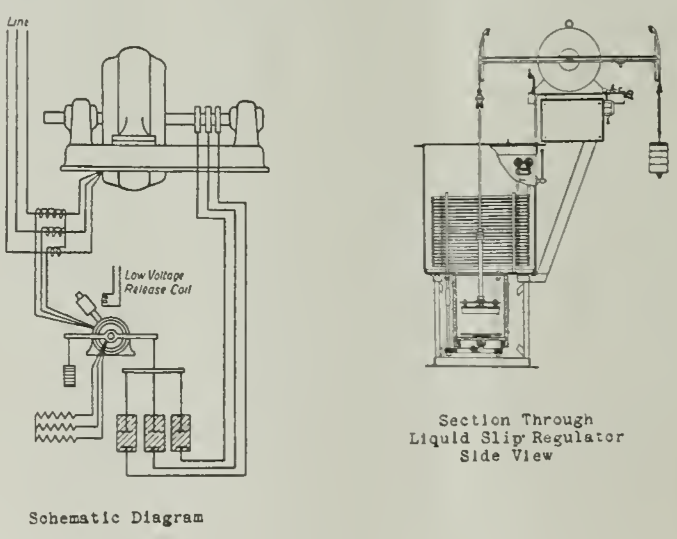
The bedplate which carries the stator and the pedestals is made of cast iron of heavy box type pattern. The machine surfaces under the frame feet are extended to one side and are provided with barring holes so the stator may be slid parallel to the shaft, thereby giving free access to both stator and rotor winding.

Control.

The controller will consist of a primary panel and a liquid slip regulator for the secondary control. The primary control is designed with electrically operated 1,200-ampere circuit breakers, one for forward and one for reverse operation. Both breakers to be controlled from a two point master controller located in the operators' pulpit. In order to determine the power requirements and input to the drive of this mill, there will be provided an indicating voltmeter, a wattmeter, a watthour meter and a curve drawing wattmeter. For protection there will be provided two CO overload relays and one CV no-voltage relay.

The liquid slip regulator shown in Figure 2 for the secondary control of this drive consists of a steel plate tank, to the bottom of which are attached three insulated cells. On the bottom of each cell is a stationary electrode. A movable electrode is suspended in each cell, these electrodes being hung from a common cross bar, which in turn is suspended from two arms mounted at the top of the tank. The rotor of the torque motor is mounted on the shaft of the rotating arms. The arms extend to the rear and are provided with adjustable counterweights, which do not quite balance the weight of the electrodes. One secondary lead of the main motor is connected to each stationary electrode. The movable electrodes are tied together mechanically and electrically by the supporting cross bar, which serves as a star connection. The circuit is completed through a solution of soda contained in the tanks and cells. Fig. 3 shows a section through the regulator, also a schematic diagram of the regulator connections.

The torque motor, which is of the wound rotor type, is supplied with energy from a 3-phase series transformer, the primary of which is in the primary circuit of the main motor. This motor is so connected that its torque is in the same direction as that of the counterweights, that is, it tends to raise the movable electrodes The torque developed by this motor is proportional to the square of the current flowing in its windings, and therefore to the square of the current in the primary of the main motor. This condition makes the equipment very sensitive and causes it to give immediate response. An auxiliary arm with a weight attached is mounted on the torque motor shaft in such a way that if released it drops and adds its weight to that of the counterweights, raising the movable electrodes to their highest position. When operating, this arm is normally held up by a low voltage release coil connected across the primary of the main motor circuit.



Schematic Diagram

Section Through Liquid Slip Regulator Side View

Fig. 3.

The liquid slip regulator is used both for starting the main motor and in connection with the flywheel for limiting the peaks on the main motor while running. Whenever power is off the main motor the voltage release coil is de-energized and the electrodes are held at their highest position. Under this condition the resistance in the secondary circuit is a maximum. In starting the motor the primary circuit is first closed. This places power on the primary with all resistance in the secondary circuit, in addition closing the circuit that raises the auxiliary arm, which is then engaged by the voltage device. Raising this arm releases the moving electrodes which start to descend. As the electrodes approach each other the resistance between them becomes less and the current in the primary of the main motor increases, increasing the torque of the torque motor. At some point the torque, due to the weight of the electrodes, will be just balanced by the compound torque of the torque motor and counterweights and the electrodes will float at this point. As the motor accelerates this condition of equilibrium is maintained, the electrodes approaching each other at a rate which maintains the input to the main motor at a constant value. When the motor reaches full speed the moving electrodes are at their lowest position and the secondary practically short circuited.

When rolling is begun the regulator automatically limits the motor input to the value for which it is set, and with the proper relation between the flywheel effect and load, will maintain approximately constant input. When the input tends to exceed the value for which the regulator is set, the torque motor causes the electrodes to separate, thereby introducing slip resistance into the motor circuit, causing a corresponding reduction in speed and allowing the flywheel to take the peak load. After the peak is past the torque motor allows the electrodes to approach each other, still maintaining the load at constant value until the motor again reaches full speed. The value of the load at which the regulator will open is easily adjusted to follow ordinary operating conditions by varying the number of counter weights. In addition the series operating transformer is provided with 80 per cent, 100 per cent, 125 per cent and 150 per cent taps to take care of larger adjustments.

In case a quick stop is desired the motor can be plugged. To do this the master controller is thrown from the forward to the reverse position, thus dropping out the primary circuit breaker for forward operation, and after the electrodes have moved to their highest position, the reverse breaker will automatically close, thus reversing the power on the main motor, which will quickly bring it to rest.

The Trend of Specifications for Steel Castings

General Discussion Covering the Important Features of Steel Castings Specifications Such as Chemical Composition, Physical Properties, Ductility and Testing.

By E. R. YOUNG*

STEEL castings from the standpoint of specifications governing physical and chemical properties, may be divided into two classes: Unannealed and annealed castings.

For unannealed castings, specifications are not ordinarily employed. In some cases the limits for chemical composition are set down in order to insure that the product will be of commercial grade and of a hardness which is readily machinable. Of course, there are special cases where a definite chemical composition is required in order to obtain certain specific properties, such as resistance to abrasion, magnetic permeability or occasionally a maximum tensile strength and where the castings may be desired in the unannealed condition. While there are specifications which cover the physical properties of unannealed castings of soft steel, it is for annealed castings that almost all of the specifications containing physical property requirements are employed.

In the early days of the industry a great number of the castings produced, and probably the majority of them, were used unannealed. When annealed material was desired it was so specified along with the physical properties which should be developed. With the increasing consumption of steel castings and the increasing variety of their uses, there has been, naturally, an accompanying refinement in quality of product, until now it is only the exceptional casting which is not annealed, unless that process be specifically waived by the purchaser. However, it is still the usual practice to specify that the castings be annealed as a preliminary to enumerating the physical properties desired, although as a matter of fact it is practically impossible consistently to meet the present ductility requirements with unannealed material, excepting perhaps the specifications for castings of soft steel.

In this progress toward higher standards, the physical property requirements specified as desirable from time to time have led the way so that steel castings are now being successfully produced under specifications which would have been considered commercially hopeless some years ago. At this time, it is interesting to survey the present standard specifications, to consider to what extent they secure what they aim to secure, to discuss some proposed changes, and to venture an opinion as to the logical course of revisions.

Chemical Composition.

One of the mooted questions in the steel industry and one which concerns the steel casting manufacturer is the question of the limits of phosphorus and sulphur. Earlier specifications set these limits at 0.050 per cent for acid open hearth steel and these were commercial up to the time of the war demand. When fuel and melting materials which would yield a finished product under these limits became difficult to secure and were needed for types of steel in which low phosphorus and sulphur were of vital importance, the phosphorus and sulphur limits for steel castings were raised to 0.06 per cent for acid steel. These limits were tentatively continued in 1919 and were adopted as standard in 1921 by the American Society for Testing Materials. Some purchasers, however, are still loath to adopt this new limit. The findings and recommendations of the joint committee on phosphorus and sulphur in steel which is now making an exhaustive study of the subject will undoubtedly prove the limits of 0.06 per cent to be entirely proper for steel castings and will probably justify a more liberal limit. It is to be hoped that this report, when forthcoming, will be of such a nature as to be conclusive on the subject and that it will be accepted as standard by all. In the meantime, the writer cannot refrain from offering some observations on the subject.

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*The author is connected with the Sales Department of the Detroit Steel Castings Company, Detroit, Mich.

It is safe to state that the objection of the average engineer or metallurgist to steel with phosphorus and sulphur over 0.05 per cent or 0.06 per cent is based partly on tradition and partly on a mental reservation regarding the shock strength of the material. It is this objection to phosphorus and sulphur based on tradition or perhaps even on prejudice which the findings of the joint committee will surely answer.

Phosphorus from 0.04 per cent to 0.06 per cent and sulphur from 0.05 to 0.07 per cent do not affect the static properties of annealed steel castings, that is the properties determined by the usual tensile and bending tests.

The writer has the data on the physical properties and chemical composition of 1,036 heats of ordnance steel (cast steel No. 2 and No. 3 U. S. Army specifications) made by the converter process, which has been analyzed to detect any variation of tensile properties with the phosphorus or the sulphur content. Four divisions or classes were made as follows:

Heats low in phosphorus—(under 0.040%)
Heats high in phosphorus—(0.055% and above)
Heats low in sulphur—(under 0.055%)
Heats high in sulphur—(0.07% and above)

The heats were segregated according to this classification and the average tensile properties and chemical composition of the heats in each class were computed. The table below gives the average properties and composition, and the number of heats included in the average in each case.

The average properties show a sensitive relation to the carbon and manganese content as would be expected. There is no suggestion of any relation to the phosphorus or the sulphur content with the possible exception of the value for yield point for the high phosphorus heats which is slightly out of line with the other average properties for these heats. This is very likely due to the average including a relatively small number of heats, and so, being unduly affected by a few low values; but, in any event, the decrease is well within the limits of error of testing and therefore unimportant.

Results of a short series of impact tests have been published which show a marked falling off in dynamic or shock strength, between .06 and .07 per cent phosphorus.* However, considering the somewhat uncertain standing of this test in the field of testing materials and, especially, the small number of tests included in the average results, it does not seem that this evidence on the subject can be regarded as final.

The writer has seen screws, bolts, etc., made of screw stock with phosphorus and sulphur both over 0.10 per cent, tested to destruction, without any weakness of material being disclosed. He has also seen steel castings with phosphorus over 0.06 per cent and sulphur over 0.075 per cent tested to destruction with no suggestion of weak or faulty material, though the uninitiated would confidently expect such tests to show the material to be decidedly inferior.

The final answer to the question of shock strength is the test of service. Perhaps there have been cases of failure of steel castings used under severe shock conditions, which have shown a high content of phosphorus and sulphur in the broken parts. Supposing that these failures have been shown to be due to faulty material and not to foundry defects or to excessive loading, the remedy is still not lower phosphorus and sulphur, but proper heat treatment. In the writer's opinion this has been conclusively shown by the work of Mr. John H. Hall and associates on the "Heat Treatment of Steel Castings."† They have shown that the lines or planes of weaker material, due to the non-uniformity or segregation promoted by phosphorus and sulphur, can be removed by quick cooling from the annealing heat, followed by reheating at the proper temperature, but cannot be prevented from forming slow cooling from the annealing heat, by any lower

Comparative Tensile Properties of Heats

High in phosphorus, low in phosphorus, high in sulphur, low in sulphur

Classification of Heats	Physical Properties					Analysis				
	No. of Heats	Field Point	Tensile Strength	Elongation Per cent	Reduction Per cent	C.	Mn.	Si.	P.	S.
Heats high in sulphur (.070 or above).......	209	44,780	80,110	22.4	28.7	.29	.71	.30	.045	.076
Heats low in sulphur (under .055).........	110	45,100	80,500	22.2	29.	.30	.70	.30	.044	.052
Heats high in phosphorus (.055 and above).....	32	43,700	81,000	21.7	28.0	.30	.72	.31	.056	.061
Heats low in phosphorus (under .040)..........	74	44,660	80,200	22.8	29.9	.29	.70	.29	.037	.065

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*F. C. Langenberg, "Impact Tests on Cast Steel," Proc. A. S. T. M., 1921, p. 810.

†"Heat Treatment of Steel Castings," Amer. Inst. Min. & Met. Engrs., Vol. LXII, p. 353.

content of phosphorus or sulphur down to 0.025 per cent.

Further evidence that an extremely low content of phosphorous and sulphur is necessary before any gain is made in the properties of carbon steel is given in an article detailing the practice of the U. S. Naval Ordnance Plant at Charleston, W. Va., by W. J. Priestley.* He shows that an increase in the figure obtained for reduction of area on tangential test bars occurs when the phosphorus and the sulphur content are reduced below 0.020 per cent. If we agree that reduction of area is a rough index of toughness and that the usual conception of shock strength is of a property which combines toughness with good elastic limit we conclude that an improvement in shock strength is not achieved by a reduction of the phosphorus and sulphur content from 0.060 to 0.025 per cent.

It is gratifying to note that recent U. S. Army specifications for caterpillar tractor links or shoes permit sulphur to 0.07 per cent and specify a heat treatment consisting of a straight anneal followed by a water quench and a draw. The tensile properties specified could readily be obtained with a simple annealing treatment indicating that the object of the heat treatment was to improve other than tensile properties.

Occasionally it is intimated that published articles and researches dealing with the question of phosphorus and sulphur are not written entirely in good faith as technical articles, but are perhaps inspired by commercial considerations. It is certainly quite clear that any producer of steel who resorted to propaganda to market an inferior article which would not function properly would be pursuing a very short-sighted policy indeed. It is equally clear, on the other hand, that any user of steel who unnecessarily insists, through ignorance or prejudice, on a costly and relatively less common product is pursuing an uneconomic policy both personally and industrially.

Physical Properties—Elastic Limit and Yield Point Specifications.

One of the frequently proposed revisions in physical property specifications is to require a reasonably accurate determination of the elastic limit, and to make this property together with the usual ductility requirements the basis for acceptance or rejection, the ultimate strength to be reported only as an item of information.

At first thought, this plan sounds very good. It is argued that the elastic limit is the property in which we are most interested. It is the property that has been used as the basis for design and it determines the point of failure in service more often than does the ultimate tensile strength. This is all true, but there are difficulties in the way of adopting this suggestion. One difficulty is that of definition, and another that of method. When we come to the question of an exact defintion of the proportional elastic limit or proportional limit (which is the property commonly determined in actual testing and which closely corresponds to the elastic limit based on permanent set) and a method of determining it in practice, we find we have nothing hard and fast for a standard. Authorities on the testing of material state that the greater the refinement of measurement and the greater the delicacy of instruments used in determining the proportional elastic limit the lower the value obtained for this property.

Granted this situation is not peculiar to steel castings, but applies to other materials similarly tested. However, most of these materials, when subjected to the standard tensile test, show an almost constant stress-strain (load-stretch) ratio within the elastic range and a definite break from a straight line in the stress-strain curve which for practical purposes it is satisfactory to take as the proportional elastic limit. Actually the value obtained here is higher than that obtained in tests of greater precision and more nearly represents the yield point, which is defined as the stress at which there is a marked increase in rate of stretch with no increase of load.

Steel castings, on the contrary, do not show a constant cross-strain ratio. The amount of stretch under uniform increases of load is very irregular and the stress-strain curve is far from a straight line from its very beginning at the point of initial load. And so there is, of course, no one point where the proportionality of stress to strain shows a marked change, i. e., no true proportional elastic limit.*

Hence, for steel castings it is not feasible to specify the elastic limit and to require its determination by the usual stress-strain curve method. The alternative is to specify the yield point and to require a more accurate determination of it than is secured when the beam of the testing machine is used as an indicator. One satisfactory method of securing greater accuracy is to use an extensometer to detect the point of greatly increased rate of stretch. Another is the method of striking an arc on the chalked or smoked surface of the specimen and watching for the first visible widening of this arc. Both of these methods are quite workable and give a close indication of the actual yield point.

The usual determination of the proportional elastic limit, as has been noted, also actually gives a close measurement of the yield point so there is no difference in the physical property measured and little difference in the value obtained under the two different requirements (where applicable). But while there is no difference in final results there is a difference in the properties originally specified and in the method of test contemplated in the specifications. And it is worth while to point out this difference for it is highly desirable that both manufacturer and purchaser realize just what properties and characteristics of the steel it is the intention to establish under test and just what the properties are, which are actually determined in the prosecution of the test.

The fact that an elastic limit specification is not readily applicable to steel castings has been taken account of in some recently proposed revisions, which specify a minimum yield point instead of a minimum elastic limit, when the tensile strength specification is omitted.

Ductility Specifications.

The new manner of specifying the ductility requirements, i. e., in terms of the tensile strength or of the elastic limit or yield point is coming into more general use. The tensile strength is the more satisfactory to use for steel castings because it can be more exactly determined and because it shows a more uniform relation to the other properties. The new specifications state that the per cent of elongation and the per cent of reduction shall be equal to certain constants divided by the tensile strength, with a fixed per cent of elongation and a fixed per cent of reduction required as a minimum for each type of steel. The intention is, seemingly, to take into account the inverse relation which exists between the tensile strength and hardness of steel on the one hand and its ductility on the other hand, and the change from the former method of specifying a definite percentage of elongation and of reduction for each class of steel regardless of strength, is very logical. But when we come to examine the percentages required as a fixed minimum we find, in some specifications, that they are set so high as to correspond to the ductility of the softest steel in each class.

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*"Sulphur and Oxide in Steel," American Inst. Min. & Met. Engrs., Feb., 1922. Iron Age, Dec. 29, 1921, p. 1658.

*Lawford H. Fry, "Tensile Properties of Steel Castngs." Proc. A. S. T. M., June, 1922.

The sliding scale set up by the formula thus becomes inoperative over almost its entire range, because the value obtained by its use is always less than the fixed minimum. In a few cases where the tensile strength is unusually low relative to the yield point, which is up to the requirement, the scale might operate. The result would be, of course, a higher ductility requirement for the steel in question than the fixed minimum.

The net result then is to raise the ductility requirements. This would not be objectionable in itself if it were the end sought and were thought necessary. But after recognizing the fact that for two steels of the same general class the one with the higher tensile strength and hardness will be less ductile than the one with the lower tensile strength and hardness, and this with no sacrifice of quality, it is illogical to turn about and say that the stronger steel must nevertheless show the ductility, expected of the one of lower strength.

New Methods of Test.

Of late much more attention is being given to the strength of materials under repeated and reversed stresses and to methods of determining this property of resistance to fatigue.

Some very interesting data have been published covering the fatigue strength of ferrous metals in the rolled condition.* While cast steel probably has different fatigue properties than rolled steel, it is likely that some of the general facts established regarding the relation of fatigue strength to other properties will prove true for cast material also.

It was found that the ultimate tensile strength bears a closer relation to the fatigue strength (endurance limit) than does the elastic limit; that neither the ultimate tensile strength nor the elastic limit have a sufficiently close relation to the endurance limit to justify their use as an index of the latter; that of the tests more commonly used, the Brinell hardness test bears the closest relation to the endurance limit and gives the most promise of serving as an index of it.

The fact that the tensile strength shows a distinct relation to the endurance limit and that the elastic limit does not, may serve to modify the present estimation of the relative importance of these two properties. With regard to cast steel, this information is particularly pertinent because, as we have seen, cast steel has no true elastic limit, while its ultimate strength is a very definite property.

Brinell Testing.

The use of the Brinell hardness test is steadily increasing in metallurgical testing because of its ease of execution and dependability and the significance of its results, especially when the action of certain material or heat-treated part, under the Brinell test, has been previously studied. For these reasons, in cases where the material is subject to 100 per cent test and inspection, the Brinell test is frequently specified by giving the limits of hardness desired. Now that some indication of the fatigue properties of the metal is also obtained by this test it will undoubtedly be employed to a still greater extent.

Brinell testing of steel castings has been done to a limited extent, largely for specific information as to hardness. The difficulty of applying the test to large pieces is an objection not easily overcome. It may be that the portable Brinell could be utilized for this purpose, though so far as the writer is aware, this adaptation of the Brinell test is not nearly so well standardized as is the regular method.

Another serious objection would be the influence of minor surface defects or non-uniformity on the Brinell tests. On the other hand we have the present method of judging the annealing of castings of various sections, by the visual examination of the fracture of an annealing lug with a section of ½ in., which it is readily admitted is a far from ideal method. In most cases where annealing lugs are used the inspection by means of their fracture is a 100 per cent operation and the Brinell test could be applied with no greater consumption of time.

With the larger use of heat treated castings which is surely coming, the Brinell test will undoubtedly be quite commonly specified.

TRUMBULL STEEL COMPANY TO ENLARGE PLANT

Plans of the Trumbull Steel Co., Warren, Ohio, provide for the installation at some future time of eight additional open hearth furnaces. The company now has a complement of seven open hearths, but its blooming mill and bar mill have sufficient capacity to roll the output of eight additional units. In recent years, the company has been gradually increasing its capacity, until it can now produce 40,000 tons of steel products per month, including billets, sheet bar, blue, black and galvanized sheets, galvanized and painted roofing, electric sheets, tin mill black, tin plate, hoops, bands and hot and cold-rolled strip steel.

It employs about 6,000 men, or nearly half the working population of Warren, and is self-contained. Its ore mines in Minnesota will take care of its present needs for 15 or 20 years. The Trumbull Coal Co., a subsidiary, operates coal mines in Greene county, Pennsylvania. The Trumbull-Cliffs Furnace Co., in which the Trumbull Steel Co. is a joint owner, operates the largest blast furnace in the Mahoning Valley, with a rating of 600 tons per day, but which can easily produce up to 700 tons daily under normal circumstances. The ore yard is 500 ft. long and has a capacity of 500,000 tons.

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*H. F. Moore and J. B. Kommers, "An Investigation of the Fatigue of Metals," Bulletin 124, Engr. Experiment Station, University of Illinois.

New Development in Rolling Mill Drive

New Electric Drive for the Hot Strip Mill of the Trumbull Steel Company at Warren, Ohio, Described

By A. K. BUSHMAN
Power and Mining Engineering Dept., General Electric Co.

AN interesting electrical equipment representing a totally new development in rolling mill drive has just gone into operation on the new 14-in. continuous hot strip mill of the Trumbull Steel Mill.

The mill itself, which was built by the Morgan Construction Company of Worcester, Mass., consists of a roughing train, having four stands of horizontal rolls, an intermediate train with two stands, and a finishing train having four stands. The roughing stands are driven by a 600-volt, shunt wound, d.c. motor which will develop 1,250 hp. (50 deg. C.) at any speed between 175 and 350 rpm. through reducing gears. The intermediate stands are driven by a similar motor direct connected to stand No. 6 and through reduction gears to stand No. 5. The four stands of the finishing mill are each driven by individual 800-hp. motors of similar design, but different speeds, which are directly connected to the rolls.

The power to operate the whole mill is furnished by two synchronous motor generators, each consisting of a 2,300-kw., 600-volt, compound wound d.c. generator direct connected to a 3,300-kva., 2,200-volt, 60-cycle, 3-phase synchronous motor. The main shunt fields of the generators and d.c. motors are separately excited from a 250-volt d.c. circuit. The electrical equipment was built by the General Electric Company.

The control which makes this drive possible does not work on the principle of maintaining a given ratio between stands, but maintains constant any speed at which a motor is set entirely independent of other motors. It is evident that this system is much simpler and more readily set up than one depending on change gears and cone pulleys and since the speeds of the various motors are constant the ratio between them must also be constant.

On the shaft of each d.c. motor there is mounted a small alternating current generator, known as the pilot generator. The fields of these generators are connected to the exciter bus which is supplied by a small motor generator controlled by a voltage regulator which maintains constant excitation on the generators, therefore the delivered voltage of any one of them will be strictly a function of the speed of the d.c. motor to which it is connected. This voltage is used to actuate a voltage regulator that cuts resistance in and out of the d.c. motor field circuit. For instance, if the motor speed drops off for any reason, the voltage of the pilot generator, being reduced, will cause the regulator to cut resistance into the motor field, weakening it, and bringing up the speed. In case the motor overspeeds beyond its set limits, a reverse action takes place. The use of an anti-hunting winding on the regulator, which causes it to break its contacts without waiting for the motor to come up to speed, prevents any hunting on the part of the motor.

If the pilot generators were operating on open circuit their generated voltage would be exactly proportional to their speed, but in order to obtain a greater degree of sensitiveness the primary of a transformer is connected in series with the regulator coil and the secondary is loaded on a bank of condensers so that a large part of the excitation of the pilot generator is derived from the heavily leading power factor of the armature current. We, therefore, have four factors tending to give a change in voltage across the regulator coil with a change in speed. First, the direct effect on the voltage due to a change of speed; second, the effect on the armature current due to a different frequency being impressed on the condensers; third, the effect of the armature current on the generator voltage; fourth, the effect of a change in speed on the power feacot of the armature current with a corresponding change in the voltage drop across the inductive transformer primary, this drop being negative for low leading power factors and positive for lagging power factor. These four effects are cumulative and cause a change in regulator coil voltage many times greater than the change in speed.

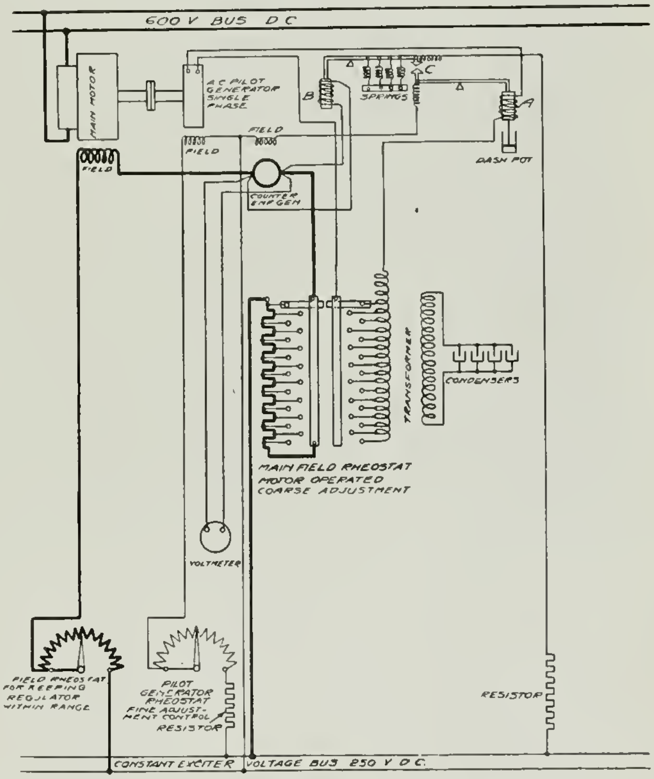

600 V BUS D C
MAIN MOTOR
A C PILOT GENERATOR SINGLE PHASE
B
SPRINGS
C
A
DASH POT
FIELD
FIELD
FIELD
COUNTER EMF GEN
TRANSFORMER
CONDENSERS
MAIN FIELD RHEOSTAT MOTOR OPERATED COARSE ADJUSTMENT
VOLTMETER
FIELD RHEOSTAT FOR KEEPING REGULATOR WITHIN RANGE
PILOT GENERATOR RHEOSTAT FINE ADJUSTMENT CONTROL
RESISTOR
RESISTOR
CONSTANT EXCITER VOLTAGE BUS 250 V D C

Fig. 1—Schematic diagram speed regulating control for d.c. motors.

Adjustments of the speed on any individual motor are made from the pulpit of the mill, by means of three rheostats, one being motor driven. The latter changes the resistance in the motor fields and adjusts the regulator coil circuit simutaneously by changing taps on the primary of the transformer. These taps are so proportioned that the voltage impressed on the regulator is constant regardless of changes in motor speed caused by the motor operated field rheostat, thus making it unnecessary to make any adjustment of the regulator for different speed settings—in other words, the regulator holds the same pilot generator voltage whether the motor is operating at maximum or minimum speed. The second rheostat makes extremely small changes in the resistance of the pilot generator field, thus allowing the operator to make slight adjustments of the speed setting that may be desirable. The third makes small changes in the main motor field without a corresponding change in the regulator coil circuit and is used in connection with a voltmeter across the armature of the counter E.M.F. generator in the field circuit to form a "range finder" to correct for changes in line voltage and keep the regulator operating in the middle portion of its range.

Looking at the diagram it will be seen that the control system is very simple and involves standard equipment only with the single exception of the transformer in the pilot generator circuit which is one-half kva. in capacity and so rugged in construction as to practically eliminate the possibility of any trouble from this source. The regulators have but one vibrating contact and one relay contact which carries the field current of the counter E.M.F. generator which is less than a quarter of an ampere. Every effort has been made to insure continuity of operation and all delicate adjustments have been avoided.

This control will hold the motor speeds constant under changing load conditions and will not allow the speed ratio to vary enough to cause loops or to pull the strip was thoroughly demonstrated in preliminary tests at the factory before the order was placed and experience with the apparatus in actual production has completely fulfilled expectations. With the aid of the extremely accurate tachometers mounted on the pulpit benchboard the mill may be set up for a different product in a very few minutes and the first piece is put through at full speed. As many as 10 different sizes of strips have been rolled in one day.

The control is so simple and easy to operate that the regular operators experienced no difficulty in handling the equipment and on the second day of rolling without special instructions put the entire equipment into operation before the factory men arrived at the plant. In fact, the first day of operation, in spite of the numerous delays for minor adjustments, such as are always necessary when breaking in new machinery, the mill produced 130 tons of strip for shipment. The mill has produced 235 tons in a single turn and this is not believed to be its maximum capacity.

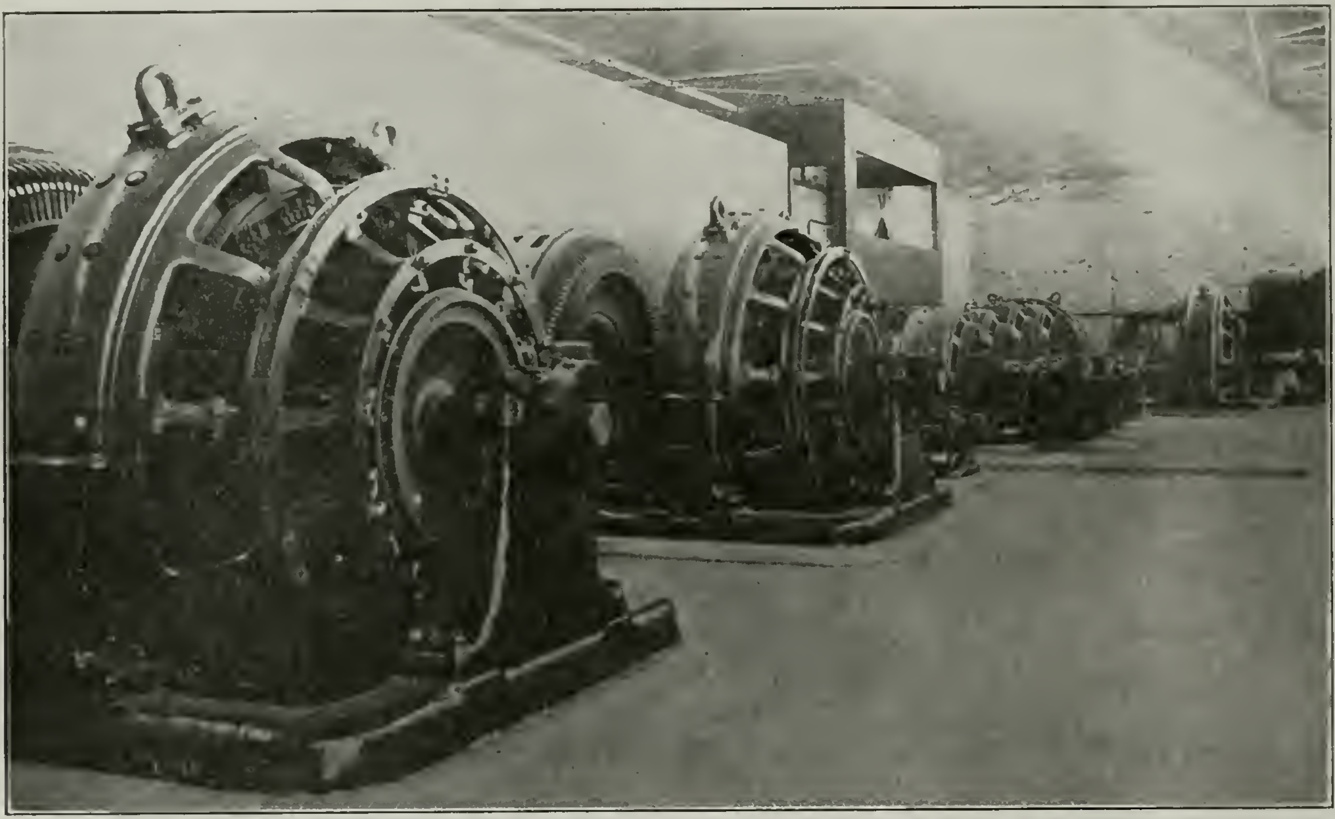


Fig. 2—Motor drive of new electrically driven hot strip mill, furnished by the General Electric Company at Trumbull Steel Company. The large machines in the foreground are motor generator sets. The mill drive is the group of machines in the background.

The continuous mill has been very highly developed by the manufacturers so that some mills produce as high as 97 per cent of their theoretical capacity over long periods of time. It is evident that very little, if any, improvement may be expected in this direction and attention has therefore been turned to increasing the flexibility of the apparatus.

Previous to this installation described, Morgan continuous strip mills have been driven from two or more sources of power through gears on the roughing and intermediate stands and through belts and pulleys on the finishing stands. In order to prevent loops or stretching of the metal the peripheral speed of the rolls of each successive stand must increase in proportion to the elongation of the metal, but since the diameter and rpm. of the rolls is fixed the reduction for each stand is also fixed as long as the initial size of the billet is unchanged. This makes the mill very inflexible and difficult to set up and to obtain some products it is necessary to start with a special size billet or even to change the rolls in some stands.

Obviously, the ideal continuous mill would have individual drive for each stand, at least on the finishing end, thus allowing the use of any desirable combination of speed and draft. This arrangement has been used for many years on tandem cold strip mills when the rolling speeds are low and the distance between stands is comparatively large so that a small change in the speed ratio of any two stands does not quickly stretch the metal or form a loop too large to handle. A high speed hot mill such as that at Trumbull, however, finishes at speeds around 2,000 feet per minute and the distance between stands is but eight or nine feet, therefore the speed ratio between stands must be maintained with an accuracy very closely approximating that of gearing. This has been successfully accomplished by means of simple and rugged apparatus.

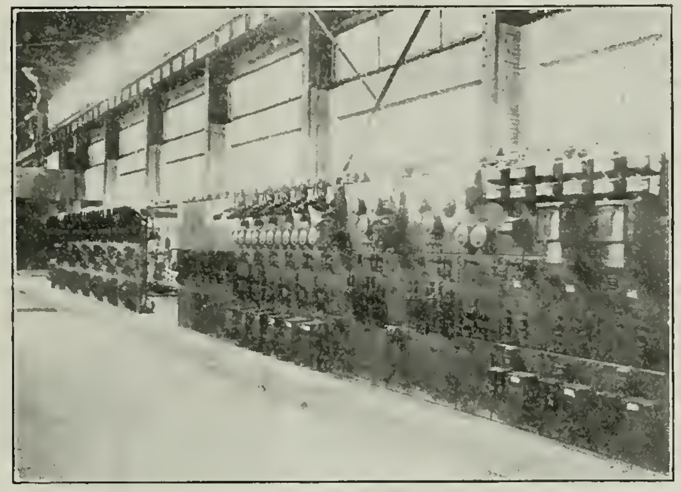


Fig. 3—Switchboard for strip mill drive at Trumbull Steel Company.

AMERICAN ELECTRICAL SOCIETY TO HOLD MEETING IN MONTREAL

Final arrangements for the forty-second general meeting of the American Electrochemical Society, at Montreal, Que., are being made which will make this meeting one of the best in the history of the society.

The meeting will be opened by President Schluederberg on Thursday morning, September 25, and the technical program will proceed with the presentation and discussion of papers on electrolysis and electroplating. The recently organized Division of Electrodeposition, G. B. Hogaboom, chairman; William Blum, secretary, will be well represented and take active part in the discussion of these papers.

One of the papers of the Thursday morning session will deal with the physical properties of electrolytic iron—a product which is being turned out commercially, contrary to all predictions of 10 years ago. There will also be papers on zinc, brass, and other electrodeposited metals.

On Thursday afternoon and Friday morning a very interesting symposium on "Industrial Heating" will be in progress. The Electrothermic Division, Bradley Stoughton, chairman; Colin G. Fink, secretary, which held a most successful symposium on "Electric Cast Iron" at the Baltimore meeting, in April last, will again be in charge. Twelve papers especially prepared for this session and dwelling on industrial heating in electric furnaces, other than fusion and melting furnaces, will be placed open to discussion.

There will be papers on:

a. "History of Industrial Heating."

b. "Principles of Design of Furnaces."

c. "Comparison of Fuel Costs in Different Types of Electric Furnaces, and With Combustion Furnaces." (In this connection electric energy would be estimated as a "fuel cost.")

d. "Resistor Materials."

e. "Specific Heats."

f. "Electric Conductivity of Insulating Materials at Industrial Furnace Temperatures."

g. "Heat Emissivity."

h. "Heat Transfer."

There will be an excursion to Shawinigan Falls, affording members a rare opportunity to inspect the various industrial plants of one of the most progressive centers on the continent. It is planned to have a special train for this all-day trip from Montreal.

A popular lecture on "The Progress in Physical Science" is scheduled for Thursday evening. Section Q will be in charge of an old-fashioned smoker on Friday evening.

The headquarters for this meeting will be the Hotel Windsor. Members and guests are urged to make their hotel reservations immediately.

M'KUNE-EGLER-DANFORTH OPEN HEARTH SYSTEMS

The Miami Metals Company, Arthur G. McKee & Company and Blair Engineering Company have announced that they have assigned the Egler, McKune and Danforth patents, together with all other patents and patent applications which they own, which relate to combustion in a regenerative furnace, to the Union Trust Company of Cleveland, Ohio, trustee, for the Open Hearth Combustion System and that the trustee is empowered to grant licenses under these patents.

This announcement is of great interest to the trade. No invention in recent years in the steel industry has attracted more favorable comment than that of the blow torch open hearth furnace.

Inasmuch as the McKune and Egler systems obtain practically the same results, it appears as if the best interests of the steel trade will be furthered by a consolidation such as has been effected. As a result of this consolidation of the interests, it is now possible for a steel plant to build a furnace incorporating the best features of both systems without being liable to suits for patent infringements.

The Blaw-Knox Company of Pittsburgh have been appointed general agents for the exclusive sale and manufacture of all equipment covered by these patents. With their plant facilities, special engineering and service departments composed of experts in open hearth design and operation, they are especially qualified for the handling of this department.

Gas Burners With High Efficiency

Feature of Burner Design by Muller Is That It Assumes a Very Intimate Mixture of Gas and Air, And That All Gas Pressure Fluctuations Are Fully Compensated for By the Burner.

By A. THAU
Coke Works Superintendent, Oxelösund in Sweden

IN his lecture before the American Iron and Steel Institute in the earlier part of last year, Walter Flanagan referred to the methods applied on American works to burn blast furnace, producer, or coke oven gas. On European works and particularly in Germany, where in accordance with the peace treaty huge quantities of fuel have to be supplied to the former enemy countries, so that an acute scarcity of fuel is felt almost everywhere, heat economy has become a subject of extreme importance and is being developed upon quite scientific lines to make use of every source of heat and to exercise the utmost economy with the available fuels. That applies in the first instance to the efficient burning of industrial gases to which the writer has also paid a good deal of attention, and giving in this article an outline of his experience with a particular class of burner which, after trying almost every available other type on the market, was eventually adopted by him. It should be emphasized in the beginning that the writer is neither directly nor indirectly interested in the construction or manufacture of the burner and advances his experience solely for the benefit of his fellow engineers abroad.

The burner of which Fig. 1 gives a rough sketch was designed by Muller, a blast furnace engineer, who during the war was faced with the serious problem to make the available quantities of blast furnace gas go round, and who, after studying closely the phenomena of combustion on the mouth of a gas burner came to the conclusion that even in the best burner design available at that time, there was great room for improvement. Therefore in 1916 introduced a burner of his own design which by 1919 was so perfected as to appear successfully on the market.

It is a comparatively simple matter to design a burner which for all intents and purposes is nothing but an injector with gas as the primer pulling in the proper amount of air theoretically required for the complete combustion of the gas. We know, however, now that it does not by any means suffice the requirements of ideal combustion to get the theoretically required amount of air or even a small excess into the burner, especially as long as the gas pressure remains fairly constant. The main problem is to get an intimate mixture between gas and air avoiding separate gas and air zones leaving the burner mouth.

In a Lancashire gas fired boiler, for instance, it has been observed that the burner drew in an excess of air over that required theoretically for complete combustion, still there was carbon monoxide present in the flue gases. The cause for this was traced back to the fact that the velocity by which gas and air passed straight through the boiler flues was so great that the gas and air zones had not sufficient time to form an intimate mixture within the boiler flues. The combustion extended right down to the chimney base accounting for the presence of CO and a great waste of heat escaping with the chimney gases. In checking the chimney draught to reduce the velocity of the combustible mixture within the boiler flues, the burner drew in less air with the result that not sufficient air was available for combustion. Therefore the temperature of the chimney gases dropped, but their contents of CO increased again. The only remedy was to reduce the gas feed to the burner so that only a very poor efficiency could be obtained.

The writer tried another much advertised type of burner with coke oven gas on a Lancashire boiler. In this burner the gas entered in the form of an annular ring all round inside the cylindrical body. The air for combustion was drawn in by a very large central nozzle fixed to the outer end of the body. The combustion was quite normal, but by a sudden unnoticed increase of gas pressure the annular gas stream by its increased volume tapered the air space down so much, that eventually no air at all was drawn in. The gas extinguished, traveled unburnt through the boiler flues and ignited in the chimney flue causing a disastrous explosion in which the writer nearly lost his life.

From the foregoing remarks the plain conclusion must be drawn that the ideal burner must be so designed as to assure the formation of a very intimate mixture of gas and air on its heating way, and that the burner must be effectively able to cope with the variations of gas pressure which cannot be avoided in the gas circuits of large works. The length which the gas flame is to have on its way of combustion is a matter of selecting the proper size of burner, able to deal with the corresponding volumes of gas and air.

The gas burner by Muller serves these requirements better than any of the many types I have had under my care for many years. Its particular feature rests with the fact, as will be seen from the sketch in Fig. 1 that by means of a number of fixed, peculiarly twisted blades, the gas entering the burner is forced to a rotating cork-screw-like motion on its way of combustion. The burner is slightly differently designed for the purposes for which it may be applied and for different kinds of gases used for heating. For use in Lancashire or Cornish boilers it is provided with channels bent outwards in the direction of the burner mouth so that the flame is thrown by centrifugal force on to the inner walls of the boiler tubes, and as the cork-screw-like rotation is maintained right through the whole length of the tubes, a very intimate contact between flame and tube plates is assured. The burner consists of a short cylindrical body, and if the flame is to be centrifugally spread out like in the case of Lancashire or Cornish boilers, the burner body increases in diameter towards its mouth, while in cases where it is desirable to retain the flame more on a central axis, like for instance, in blast furnace stoves, the burner body is best tapered towards its mouth.

The front portion of the burner is divided by fixed and twisted plates into a number of radially distributed compartments, of which to everyone connected to the gas delivery, the two on each side of it are open to the atmosphere serving as air inlets. By the peculiar twist of the blades forming the gas and air chambers, the partitions form together a screw with different pitch for gas and air so that the free area left is differently proportioned in accordance with the heating value of the gas. In front of the housing holding the gas and air chambers is a distributing space for the gas, connected by means of a valve to the gas supply main. The air for combustion is automatically drawn in by the gas. The burner differs from nearly all others in that it is not at all attempted to force the gas and air into an intimate mixture inside the burner body, but upon leaving the burner mouth, gas and air are divided into a number of fine streams being distributed over the periphery in proper rotation. The way by which gas and air leave this burner and enter for instance a boiler tube can best be explained by comparing it with rope making. Like in rope making, the single threads are issued over a distributing ring, and by turning round all the time, for a thick rope which keeps also turning all the time, so shoot from this burner thin streams of air and gas through the annular burner mouth, forming inside the boiler tube a large hollow rotating column like a hollow rope. It is very interesting to observe this rotating combustion by throwing a small fairly hard pressed ball of paper into the burner, and its spiral passage through the whole length of the tube can be very plainly observed. To attain such a way of combustion was a great step forward, since with most other burners in which the flame burns simply on a horizontal axis into the tubes, an intimate contact by which every single spot of the inner tube plate is covered by the flame cannot be attained without a great excess of heat and consequent waste in the chimney flue.

While in the case of blast furnace gas the required mixture for combustion is about 1:1, with coke oven gas the proportion is about 5:1, so that in the latter case the number of chambers dividing gas and air into single streams is largely increased, compared with the former to ensure an intimate mixture and complete combustion. The whole burner is made of cast iron to ensure a tight separation between gas and air distributing chambers since leaks would cause a pre-ignition or a back firing and would disturb the proper operation. For the same reason must the burner be tightly fixed to the boiler face to prevent any air from entering the combustion flue except through the proper channels in the burner itself.

In the case of blast furnace stoves, the burner is fixed at the base projecting into the combustion chamber and such a special design is applied that the combustion products rise in the central shaft of the Cowper. This precaution is being taken as otherwise if the flames were allowed to impinge upon the brick work inside the stove, the walls would suffer too much. This effect is, as already mentioned, being reached by giving the burner body a certain taper towards its mouth contrary to the shape applied to Lancashire or Cornish boilers.

To illustrate the operation of the burner a few average figures are added from the daily returns of the works referring to Lancashire boilers heated by blast furnace gas.

Calorific value of gas:
1006 Cal./cbm., 113 Btu./cbft.

Analysis of gas:

CO_2	12.2%
CO	28.0%
Cn Hn	0.4%
H_2	3.6%
O_2	0.0%
N_2	55.8%
	100.00

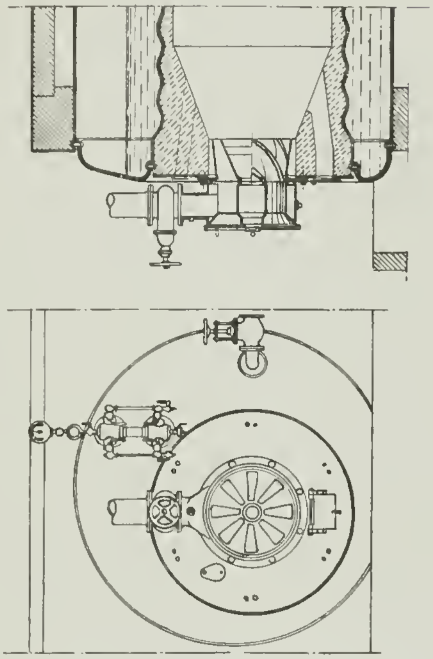


Fig. 1—Diagram of the burner.

Temperature of gas	12 deg. C.	54 deg. F.
Gas pressure in main line	150 mm.	6" WG.
Gas pressure between valve and burner	80-100 mm.	3-4" WG.
Draught on back end of boiler tubes	22-25 mm.	⅞-1" WG.
Draught in chimney flue	29 mm.	1⅛" WG.
Temperature on back end of boiler tubes	540 deg. C.	1004 deg. F.
Temperature of chimney gases	180 deg. C.	356 deg. F.

Analysis of combustion products:

CO_2	25.0%
O_2	traces
CO	nil

Steam raised per hour—29-31 kg. per m² heating surface = 5.945-6.355 lb. per square foot heating surface.

Steam pressure in boiler—6-7 atmospheres 88.2-102.9 lb. per square inch.

Feed water temperature—56 deg. C., 133 deg. F.

Possible increase over normal capacity—40%.

While with the former burners which were replaced by those of Muller the gas consumption was 1.1-1.2 cbm. per kg, steam = 17.61-1921 cbft. per lb. steam. This figure was improved upon by the new burner to 0.844-0.881 cbm. gas per 1 kg. steam = 13.51-14.15 cbft. of gas per lb. steam, being equal to a saving of 15-17 per cent.

The heat developed by this burner is much more intense compared with the formerly adopted types, and while formerly 650-750 deg. C. = 1202-1382 deg. F. were reached, an average of 800 deg. C. = 1472 deg. F. can now be maintained without special efforts.

The increase of temperature makes itself favorably felt in the heating of blast furnace stoves. By driving the stack moderately it can be assumed that one Cowper is two hours under wind and two stoves heating for six hours. This mode of working was considerably improved upon by equipping the stoves with Muller burners with the result that by the quicker heating instead of three or two Cowpers being heated only two or one are required. By these means the work of the man in charge was greatly reduced. In case of new plants it may even be possible to reduce the number of stoves by one and on plants with existing Cowpers, one stove may be set apart as a stand by.

By reducing the number of stoves and shortening the way of the hot blast mains a further saving of heat is effected by reducing the surface area losing heat by radiation depending of course greatly upon local conditions.

Since 1919, when the trials with the first designs were concluded under all possible conditions, over 300 burners of this type have been introduced for all purposes where industrial gases are used for heating, viz: Boilers, stoves, reheating furnaces, forges, also for the heating up of steel converters and ladles and for industrial furnaces of any kind.

These burners have remarkable properties to cope with even the most severe fluctuations of gas pressure. Back firing is practically unknown. Two pressure charts, taken from Lancashire boilers, were recently compared. One of the boilers was heated by coke oven gas, while the other was heated by blast furnace gas. Comparing the two charts, it was found that the contents of CO_2 in the flue gases remain almost constant showing that the great pressure fluctuations as recorded on the gas pressure chart are fully compensated by the burner.

With the coke oven gas the CO_2 contents averaged about 9.5 per cent with the blast furnace gas 22.5 per cent. A boiler efficiency of 85-87 per cent is being continuously maintained as long as the boilers are fairly clean and in case of blast furnace gas when the contents of dust are not too high.

AMERICAN ELECTROCHEMICAL SOCIETY'S FALL MEETING

Final arrangements for the forty-second general meeting ofthe American Electrochemical Society, at Montreal, Que., September 21, 22 and 23, are being made. The technical program for Thursday, September 21, will include papers on electrolysis and electroplating. The recently organized division on electrodeposition (G. B. Hogaboom, chairman: William Blum, secretary,) will be well represented and take active part in the discussion. One of the papers will deal with the physical proprties of electrolytic iron. There will also be papers on zinc, brass and other electro deposited metals.

On Thursday afternoon and Friday morning a symposium on "Industrial Heating" will be in progress. The electrothermic division (Bradley Stoughton, chairman; Colin G. Fink, secretary,) which held a successful symposium on "Electric Cast Iron" at the Baltimore meeting, in April, will again be in charge. Twelve papers especially prepared for this session and dwelling on industrial heating in electric furnaces, will cover history of industrial heating; principles of design of furnaces; comparison of fuel costs in different types of electric furnaces, and with combustion furnaces (in this connection, electric energy would be estimated as a "fuel cost"); resister materials; specific heats; electric conductivity of isulating materials at industrial furnace temperatures; heat emissivity, and heat transfer.

There will be an excursion to Shawinigan Falls to inspect the various industrial plants of one of the most interesting centers on the continent. A popular lecture on the "Progress in Physical Science" is scheduled for Thursday evening. Section Q will be in charge of an old-fashioned smoker on Friday evening. The headquarters for this meeting will be the Hotel Windsor.

PROFESSOR STUMPF ENTERTAINED

Prof. Johann Stumpf, Berlin, Germany, inventor of the Unaflow engine, who is making a tour of the United States, was the guest of Manager Neil C. Lamont, Laidlaw Works of the Worthington Pump & Machinery Corporation, Cincinnati, on August 22. Mr. Lamont had invited the members of the American Society of Mechanical Engineers, Cincinnati branch, to meet at the plant for the purpose of inspecting the latest type of engines and compressors and also to hear Professor Stumpf deliver an address on the latest developments in the Unaflow engine. Following an inspection of the shops and a number of engines in operation, dinner was served in the dining room at the plant, at which, in addition to the visiting engineers, officials and shop foremen of the company were present.

EXPLOSION WHEN GAS IS TURNED OFF

Under the above heading, a paper was read before the Societe de l'Industrie du Gas en France by M. L. Causse.

Comment is made upon the fact that while at times no explosion takes place, at other times it is considerably retarded, and in general, varies in intensity.

Explosions never occur where there is a pre-admixture of air, and the latter should enter, therefore, while the residual gas is leaving the apparatus. The residual gas leaves the apparatus because it is lighter than air, and, in addition, because it is warm.

Tests have been made with a view to retarding the explosion, whereby the phenomenon could be brought more readily under experimental observation. An illustration is given of an apparatus which has been designed whereby it is possible to ascertain what happens prior to the explosion, what determines the moment of explosion, and also what determines the greater or smaller force of the explosion.

Minute details are given relative to what happens during the first period, the explosion itself, the causes of delay and the force of the explosion. It is shown that this latter is a complicated phenomenon which brings into play all the characteristic properties of a gas and enables many incidental problems to be worked out, particularly with the aid of self-registering contrivances, and in this respect reference is made to an apparatus which has been devised by the author, based on the principle of automatic recording of the time interval which elapses before the explosion takes place after the gas is shut off.

A Study of Valves For Furnaces

Operating Difficulties and Problems Which Result from the Design of Reversing Valves for Regenerative Furnaces.

By HAAKON HELLAN

PRODUCER gas is now pretty well recognized as the most satisfactory fuel for heating furnaces and open hearth furnaces. The furnace men like it for its smooth and even heat, and it is not by far so dangerous as the richer gases, such as by-product and natural gas. With the elimination of natural gas for industrial purposes, the producer gas is bound to find a more extensive use than at the present. Although it has been in use for some time, there are still many problems in connection with it that are yet little understood.

Great improvements in arrangement of flues have been made in the last few years by engineers who have specialized in this line, but the majority of the steel plant engineers have not kept posted on the progress made, and a good many troubles from dust collection, tar, and poor gas could probably have been avoided if the problem was tackled with the right understanding.

The regenerative method for preheating gas and air enables us to obtain temperatures in the furnaces sufficiently high for almost all purposes. In a furnace plant lay-out the furnaces with regenerators are generally located in a building by themselves, and the gas producers are housed in a separate building parallel to the furnace building. These units are connected by flues both over and under ground which conduct gas and air to the furnace and which dispose of the combustion gases from the process. Valves and dampers are used to control the flow of these gases. The whole flue layout depends upon the kind of valves that are employed, as does also the efficiency of the furnace. It is therefore of utmost importance to use valves that will satisfy their purpose without any detriment to the operation. We must distinguish between shut-off valves, regulating valves and reversing valves.

Shut-off valves on the gas line are used to close off some part of the flue system from the main and are used rarely. Their principal uses are in case of trouble or when the furnace goes down and is put on. A horizontal sand damper used to be the most common contrivance for this purpose, but a cast iron mushroom valve (Fig. 1) is more easily operated and can be conveniently arranged. Gate valves are very common for shutting off producers to the gas main, but are also used where the valve is wanted in a horizontal run. The valves are kept tight against the seat by keys, which have to be tightened and released every time the valves are used.

To regulate the gas and air a butterfly valve, a mushroom valve or a damper can be used. Butterfly valves are common for overhead gas flues. When the mushroom type is used we can get along with the same valve for both shutting off and to regulate, but it must be made to withstand the excess heat. Dampers are generally used to regulate areas of underground flues and are provided also for control of waste gases from the furnace and to regulate the stack draft.

When the checkers in the regenerative chambers have given up enough heat to become noticeable on the furnace temperature the direction of the gases is reversed.

The angle valve (Fig. 1) as it is used for shut-off valve on the gas main and burn-out valve to the stack has a cast iron mushroom valve that seats itself on an iron ring. It is often necessary to sand these valves to prevent leakage, and the sand is thrown in through a door on the side of the valve box. Two such valves (Fig. 2), both connected with the furnace flue and alternatingly opened, was the logical step towards reversing valves. The air valve (Fig. 3) is of a similar construction, only the intake is at the top of the valve box, and the opening is regulated by varying the lift. The gas valves did not stand up in the heat, and before they were used long the valves and stems were made hollow and watercooled, as in Fig. 4. They also proved difficult to keep tight, and an annular water trough was provided to furnish the seal in connection with a depending edge on the valve, as shown in Fig. 5. In some cases the valve falls down on the edge of the bottom pan and rests on it when closed, but it is better practice to limit the stroke, so that the valve seals properly into water without touching the pan.

The Knox reversing valve system, which is being used quite extensively, consists of mushroom valves in connection with inclined dampers which close and open for the waste gases to the stack. The gas valve, both dampers and the seats are watercooled. Gas is admitted directly from the gas main without going underground, and the waste gases are delivered directly into the stack flue without compelling them to go through the valve. The valves are shown in Figs. 6 and 7. Two gas valves and two air valves are needed for one furnace, and each valve has its damper. The valves and dampers operate with a few seconds interval, and about 30 seconds are required for a complete reversal. This interrupts to some extent the operation of the furnace and the process. The air valve area is regulated from a stand above.

The mushroom valves in original or improved form always required much room, as every valve had three ports and there were always four valves required. A great saving of space was affected by arranging the gas and air valve boxes over their respective boxes for stack valves, as shown in Figs. 8 and 9. This permitted the gas to enter from above, directly from the gas main, an advantage that eliminates a lot of trouble from soot collection in an underground pocket. The water enters the valve stem at the top through a flexible hose, is then conducted through a small pipe inside the valve stem down to the bottom flange, from where it rises and overflows through another small pipe into the open valve. From the valve the water flows into the bottom pan through a notch in the outer edge, or some valves. Some valves have an elaborate contrivance of telescoping pipe sections to conduct the water into the bottom pan. In its top position the gas valve seals off to the main by a watercooled diaphragm. The air valve is closed to the atmosphere in a similar way, but the diaphragm in this case is made of just one plate, no water cooling being necessary. The valve area is regulated by two half-circular plates hinged on the diagonal. The other great advantage these valves have over the three port mushroom valves is their simple arrangement of underground flues. (See diagram, Fig. 16.) If the valves did not possess one very objectionable feature they would doubtless have become more generally used. Whenever gas is brought in contact with open water, it cools off and absorbs the moisture, which is carried along to the furnace as a burden. Water is also easily splashed over into ports and flues, from where it has to be evaporated by the waste gases at the expense of draft. Besides, it does a lot of damage to the brickwork.

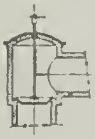


FIG 1

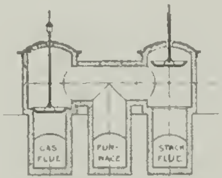


FIG 2

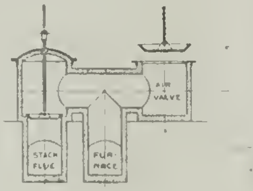


FIG 3

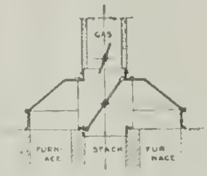


FIG 10

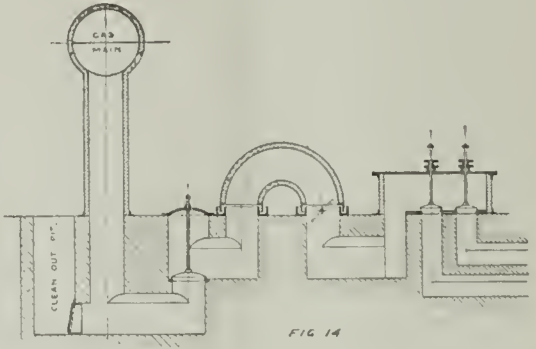


FIG 14

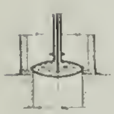


FIG 4

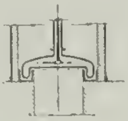


FIG 5

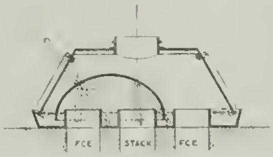


FIG 11

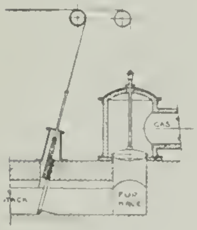


FIG 6

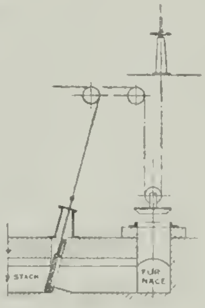


FIG 7

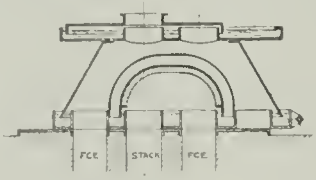


FIG 12

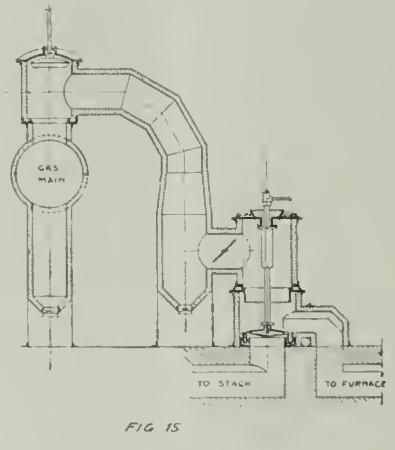


FIG 15

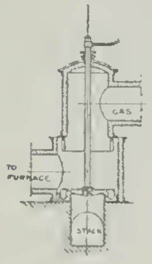


FIG 8

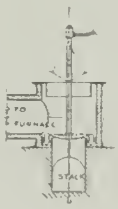


FIG 9

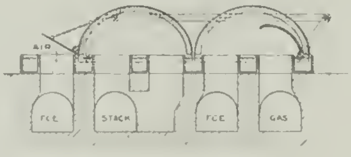


FIG 13

From another type is developed an entirely different group of reversing valves. The original "butterfly" valve, or Siemens valve, is shown in Fig. 10. It consists simply of a cast iron plate rocked back and forth when reversing and fitted against seats on the cast iron casing. The valve is extremely simple to install and operate, as well as low in first cost. But there is often considerable trouble due to warping of the valve occasioned by hot gases on one side and comparatively cool gases on the other. Attempts have been made to overcome this by watercooling both valve and casing, but without great success. There is also at times leakage at the seat, due to the deposit of soot and tar, which prevents the valve from closing tightly. Another difficulty with this valve was the leakge around the edges of the casing. Air was drawn into the gas flues, causing unexpected explosions in the flues and the furnace, and the valve casing suffered and was sometimes burnt up in a week. It was necessary to have a supply of castings on hand at all times. Still the valves are being used for both gas and air, the air valve having an adjustable mushroom valve to regulate the opening at the top.

The Forter valve substituted the butterfly with a moveable hood and swung it by one pair of rocker arms from one position to another. An improvement of this valve is the Wellman-Seaver-Morgan valve, shown in Fig. 11. The hood is here carried by two pairs of rockerarms, but arranged on the outside of the casing and thus protected from the hot gas.

A valve that is the same in principle, but operates by moving both the hood, pan and the casing on an iron seat, is the Schild valve (Fig. 12).

All these valves receive the gas at the top and require a very simple flue lay-out (Fig. 18). A recent valve on somewhat the same principle is the Isley valve (Fig, 13). It has two brick-lined hoods, connected and operated by a system of parallel levers. Two valves are required for one furnace. The one in Fig. 13 is open for gas and air to one side of the furnace, while the other connects the furnace flues to the stack. The valves require more space than any other. The gas has to be brought underground to the valve and there is the same difficulty with water as mentioned before. A diagram of the flue lay-out is shown in Fig. 19.

A type of reversing valve alone is the Blair valve. Its main feature is the refractory lined bent tube, which has one end always connected with the furnace and the other alternatingly connected to the underground gas flue or to the stack flue. There are three valves needed for one furnace, two for gas and one for air. In the case of the air valve the tube is used to conduct the waste gases from the air regenerators to the stack, while the uncovered port is the air valve, which is regulated by a butterfly valve. A diagram of the flue layout is shown in Fig 17, and Fig. 14 is a cross section of gas valves and flues in connection with regulating valves for a pit furnace. The gas is conducted through a vertical leg to an underground flue, where it can be shut off and opened by the mushroom valve at will. Before the tube is removed the valve is closed, and very little gas is lost. The tube is operated on a track by a motor or a hydraulic cylinder. The base casting is watercooled and the ends of the tubes make a perfect seal into the water, when in position. The section shows plainly the expensive underground flue arrangement; and the added cost of keeping the flues clean and maintaining the brickwork gives this valve a distinct disadvantage, as compared with other valves of recent make. Another feature is the location of the gas chambers on the outside of the air chambers, an arrangement which leads to greater radiation losses.

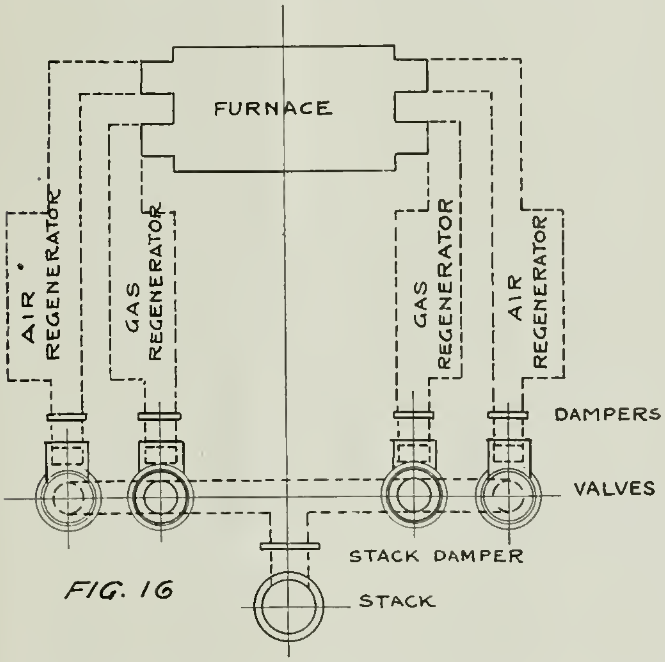


FIG. 16

The reversing valves just described comprise the types that are now quite generally used. We have noted the good points and disadvantages of them all and are able to judge what is desirable and what should be avoided in such valves. Some people are in favor of one type and have a prejudice against another, although quite often the principle of the valve is not so much at fault as the circumstances under which they are used. The reversing mechanism for mushroom valves is very often designed with an erroneous object in view, and the valves are blamed for troubles arising from this. Some other types have the valves operated in pairs, other valves are independently operated and counterweighted. Some take longer time to reverse than others. One difficulty they all have tried to eliminate is the explosions in the flues due to the gas and air mixing on their way to the stack after a reversal. Another trouble closely related to this is the feature of the gas being short circuited to the stack during the short period of the reversal. This latter point is stressed a good deal by some manufacturers and used as an argument for their valves, which have been built to meet this trouble. When we consider that the reversal of an individual valve hardly takes more than one or two seconds, and during that time is only partly open, very little gas can be lost due to this source as compared with all the gas trapped in the checker chamber and flues, and which has to be driven out through the stack. Let us suppose we have a 36-in. gas valve for a 70-ton open hearth furnace connected to two gas producers, each gasifying 3,000 lbs. of coal per hour.

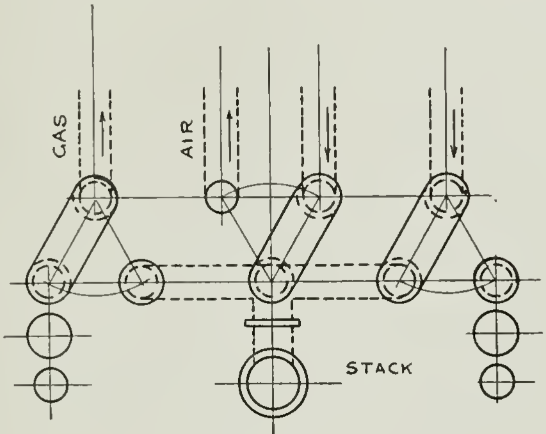


FIG. 17

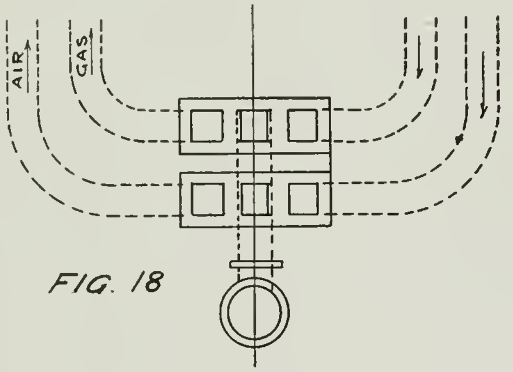


FIG. 18

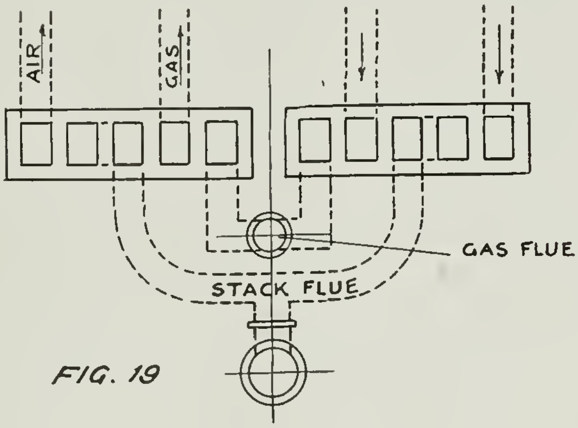


FIG. 19

The amount of gas produced per hour = 2 × 3,000 × 60 = 360,000 cu. ft. per hour, or 100 cu. ft. per second. Area of 3-ft. valve = 7 sq. ft. Velocity of gas = 100/7 = 14.3 ft. per sec. It takes about one second to reverse the valve and in that time we can assume it to be half open at an average. The loss of gas will be = 14.3 × 7 × ½ = 50 cu. ft. per reversal, or for four reversals per hour = 50 × 4 = 200 cu. ft. per hour. In a year of 300 days' operation this loss represents 200 × 24 × 300 = 1,440,000 cu. ft.—1 ton of coal @ 2,000 lbs. = 120,000 cu. ft. of gas. The loss of gas due to this source will then become equivalent to:

$$\frac{1,440,000}{120,000} = 12 \text{ tons of coal per year.}$$

At the same time the loss of gas in the checker chambers and flues can be computed for a chamber of 2,000 cu. ft., and the loss would represent:

$$\frac{2,000 \times 4 \times 24 \times 300}{120,000} = 480 \text{ tons of coal per year,}$$

which would be a considerable item if the plant has many large furnaces.

An explosive mixture and a spark or a sufficiently high temperature are required to cause an explosion. Assuming that we always get an explosive mixture, a spark can be carried as a glowing soot-particle in the gas at any time, and this danger is no less if gas and air valves were reversed with a few seconds interval than if they were reversed at the same time. Regarding the danger of explosion due to a high temperature of the mixture, we find this condition, that the gas and air just entered the valves on the way to the furnace both are at their lowest temperature, and the sooner they are brought together the lower the temperature, and the less the danger from explosion. By quickly and simultaneously reversing both gas and air valves, we would mix cold air and unregenerated gas. It is therefore quite obvious that quick acting valves all operating together is the most logical solution of the problem. It must also be evident that to close the valves on the main (gas flue) before changing the reversing valves is entirely unnecessary and does not prevent anything, just delays the operation.

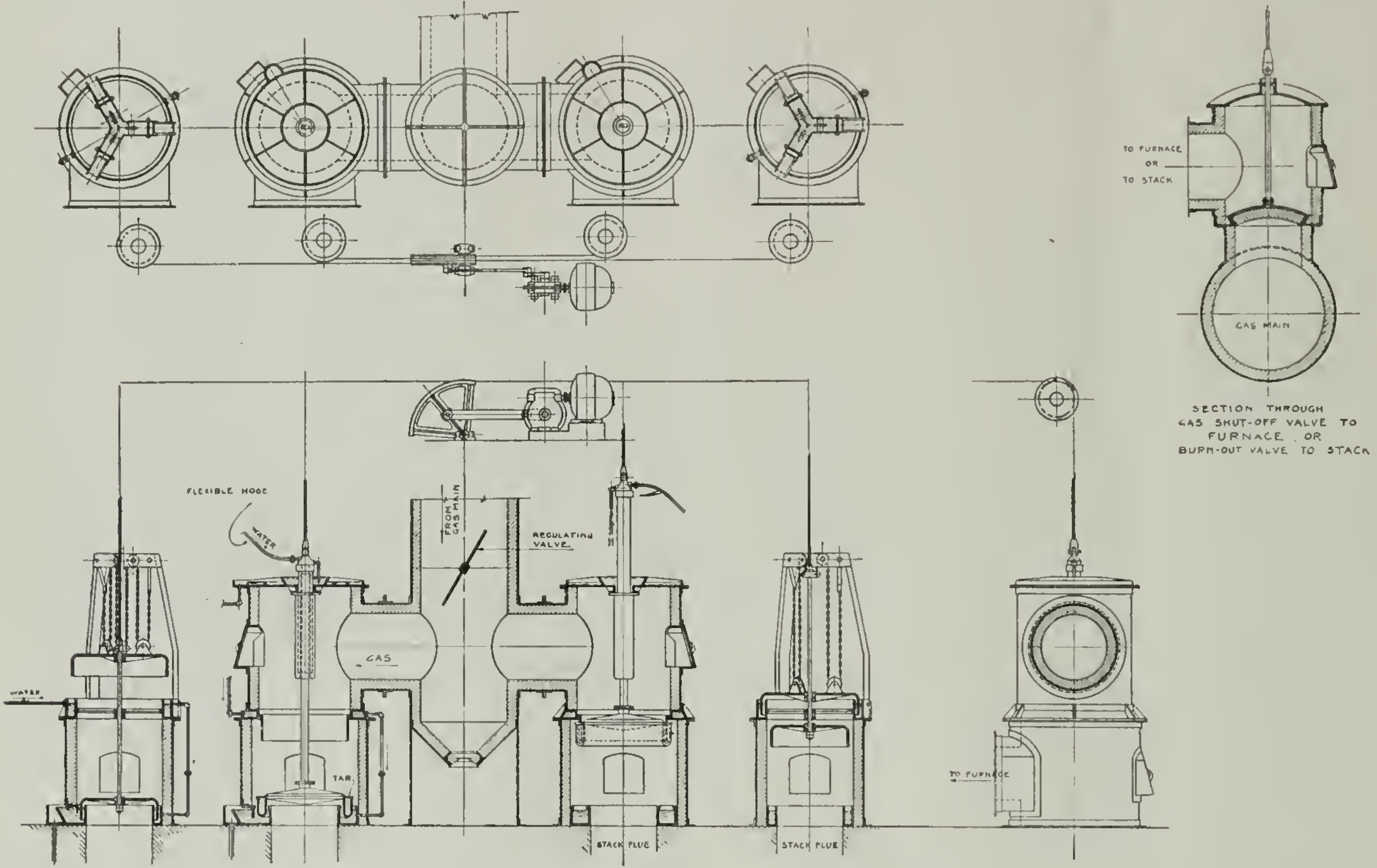


Fig. 20.

The size of air valve is often made longer than the gas valve, as the amount of air required for combustion is about 1 gas to abt. 1.33 air of the same temperature and pressure. The gas has a temperature of about 1,000 deg. F. through the valve, and the temperature of the air is about 62 deg. F. Under constant pressure, the volume of air is directly proportionate to its absolute temperature, or

$$\frac{V_1}{V_2} = \frac{T_1}{T_2} = \frac{62 + 460}{1000 + 460} = \frac{522}{1460}$$

V_1 = vol. of gas at 62 deg. and V_2 vol. at 1,000 deg. Amount of air at 62 deg. required for combustion = $\frac{522}{1460} \times 1.33 = 0.48\ V_1$.

In other words, an air valve of an area equal to 0.48 of the gas valve area would be sufficient to supply the necessary air for complete combustion. Gas has an initial pressure at the producers of about 1½ in. w. g., but most of this is lost before it reaches the reversing valves. We can safely figure that gas and air go through the valves under the same pressure, and the stack is generally the medium for drawing both gas and air into the furnace and dispose of the waste gases into the atmosphere. The gas checkers and flues get clogged up with soot and dust while the air flues stay nearly clean. On the other hand, the air regenerative chamber is usually larger than the gas chamber, because more heat has to be stored in the air checkers by the outflowing waste gases, requiring a greater proportion of these gases to go through the air chamber. This furnishes the only reason for large ports to the furnace and stack on the air valve. However, the combustion gases occupy 7 per cent smaller volume than the combined gas and air, when cooled off to the same temperature as these, and when we consider that the gas checkers will always stay much hotter than the air checkers at the valve end, almost twice as much combustion gases will flow through the air valve as compared with a gas valve of the same area.

To regulate the flow of gas and air a method should be used for constricting the areas at the reversing valves. For controlling the waste gases a furnace damper in each flue between checker chambers and valves should be used. In this way only can the process be under perfect control. In winter time the air opening must be less than in the summer. An excess of cold air into the furnace is nearly as much of a detriment to the operation as too little air. A surplus of air will have to be heated to furnace temperature, but a surplus of gas will mean a direct loss of gas to the atmosphere.

The valve system for a pit furnace requires special arrangements, as the gas and air is distributed and regulated for each pit on the furnace side of the reversing valves.

When soot and dust collect in the gas main, we get the cleanest gas at the top. An outlet at the bottom like Fig. 14 will serve as a dustcatcher. But in spite of this, we find it very common to see a gas outlet to a furnace underneath the main, and the flue run underground to the reversing valves. How easily the flue areas get clogged up with such an arrangement any furnace man can testify to. Some times it is necessary to burn out more than once a week. The gas ought to be taken off at the top, as in Fig. 15, and the shut-off valve for the furnace should be located right at the main. No watercooling is desirable on this valve, as this would require special attention in the winter.

A water seal of about 3 or 4 inches at the valve ports is always a guarantee against leaks. It can easily be arranged by having the valve project into the water of a pan, the shape of which will have to suit the particular valve. Water has so far been the only liquid used as a sealing medium. It has an advantage in that it can so easily be supplied and disposed of, but, as mentioned before, it also has some very serious drawbacks.

The gas as it leaves the producer carries along with it from 6 to 10 gallons of tar per ton of coal, gasified. A lot of this tar collects in the mains and can sometimes be seen dripping out of a leaky joint. If some of the tar were caught at the gas valve and used as a sealing liquid, there can be no reason why such an arrangement would not have some superior features over any existing gas valve. It is a known fact that a large amount of tar is precipitated at the valves, due to the watercooling. If we shape this valve to collect the tar, as in Fig. 20, we have a dependable seal, as it is raised up against the diaphragm, which shuts off to the gas main.

The writer has just applied for patent on a valve of this type, in which gas valve, air valve and reversing mechanism have been carefully designed to eliminate all the troubles with the present valves. The problems can be summarized briefly as follows:

The impact on seats when closing.

The abundance of open water for seal and cooling.

The complications of flue lay-out due to gas entering underneath the valve.

The dust collecting in flues adjacent to the valves.

To improve the mushroom valve to meet these conditions seemed easy, and it developed a system of reversing valves which now will be described. A general arrangement of valves is shown in Fig. 20 and a flue diagram is shown in Fig. 16. The gas enters from above and leaves most of the dust in the dustcatcher between the gas valves. In open position the valve seals over the port to the stack, with a deep trough around the valve proper. The trough is made of steel casting and is separate from the valve, and is held in position by keys. The tar is collected into this trough as it is knocked out of the gas by contact with the watercooled surfaces. In starting the operation, the trough must be filled with tar, and as it collects it overruns into the water pan at the bottom and is drained off with the water. In the lower position the tar is kept comparatively cool by the water, and in the top position, where it shuts off the gas, it is not subjected to heat from the sweeping gas. It is cooled to some extent also by radiation to the waterbox, which supports the top valve chamber. The cylindrical diaphragm which is used for a seal, is also a steel casting, and is hung on a seat of the water box. In starting up cold on a winter day the tar may be solid, and the diaphragm is then made to raise up with the valve until it becomes heated and sinks down on its seat. The valve and valve stem are watercooled, the water being supplied through a flexible hose.

The air valve has two bells, with corresponding water pans. There is no objection to the water here, as the air is taken in cold. The bell at the top has only half the stroke of the lower bell over the stack flue, and is so arranged that only half of its weight will act against the other bell. The valve area is regulated by a sector shaped plate resting on the ledge on the inside of the top water pan. One-third of the area is a solid rib, and the remaining 240 degs. can be reduced by the sector to whatever opening is required.

All the valves are operated together and have an absolute limited stroke, that will not permit the tar troughs and the bells of air valve to touch their waterpans. The motor directly drives a worm and wormwheel. On the wormwheel shaft is fastened a crank lever, which swings from one dead center to the other during a reversal, and the motion of the valves start from nothing, speeds up in the middle position and retards very gradually at the other end of the stroke. The crank lever connects through a link with a drum sector that has a groove for each rope from the four valves. The reversal is made in one or two seconds, and hardly any interruption is made to the operation of the furnace.

Emporium Iron Company Rebuild Furnace

Arthur G. McKee & Company Have Completed Reconstruction Work on the Emporium Iron Company's Furnace, Emporium, Pa. —Mechanical Equipment Installed to Eliminate Human Labor.

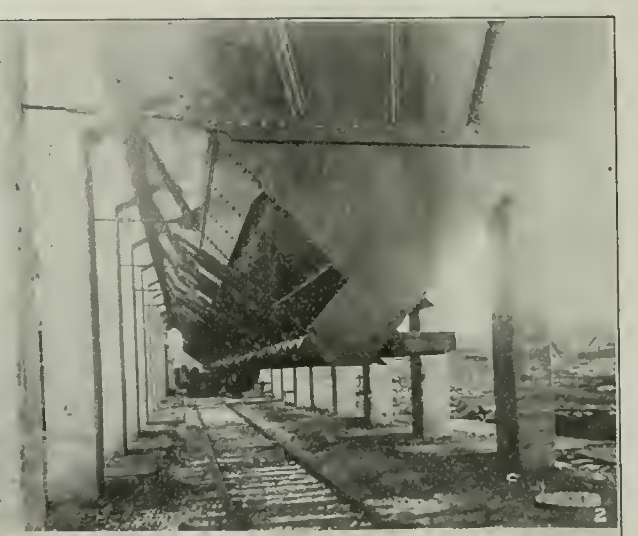
THE increasingly evident necessity of eliminating the human element in blast furnace operation and substituting mechanical equipment has again been demonstrated in recent plant reconstruction of the Emporium Iron Company, Emporium, Pa.

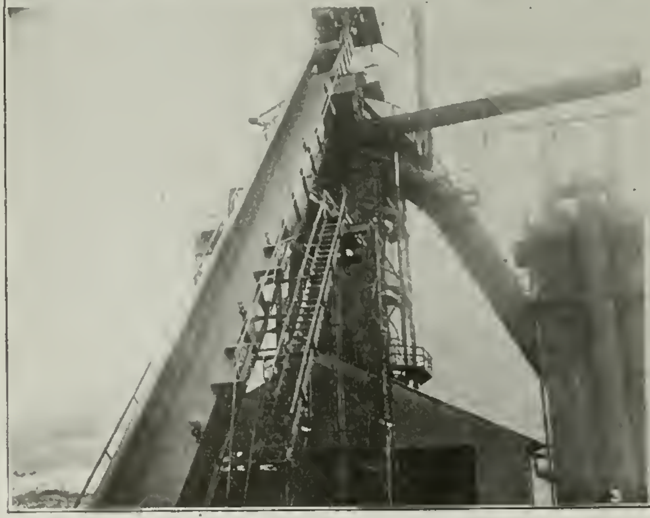
This plant, built during the years 1887-88, has operated since that time with substantially the original equipment. However, during the past year, the management decided upon radical changes and have replaced the old hand-filling system with a complete new set of storage bins, skip bridge, furnace top, etc. The furnace has been relined and partially remodeled, and new mechanical pig casting equipment installed.

Arthur G. McKee & Company, of Cleveland, were selected as engineers and contractors for the reconstruction work, their services including designing, furnishing of materials and the erection of same.

The alterations to the furnace below the mantle consisted of installing a new hearth jacket, 80 ft. deep by 16 ft. 4 in. inside diameter, made up of 1⅛-in. steel plate. Twenty-one cast iron hearth cooling plates were provided, approximately 8 ft. long by 2 ft. wide and 3 in thick. The old copper coolers were utilized, no new copper being furnished. Eight new tuyere stocks were installed, including elbows, blow pipes and base castings for attaching to the bustle pipe.

The storage bin and trestle structure is of steel and reinforced concrete, approximately 432 ft. long, and is





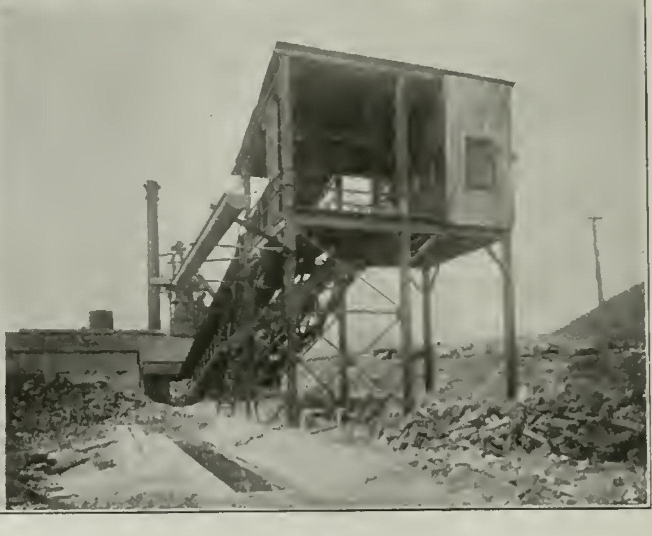


Fig. 1—Ship bridge arrangement.
Fig. 3—View of top of furnace.

Fig. 2—New bin arrangement.
Fig. 4—New mechanical pig-casting equipment.

shown in the adjacent photographs. The coke bin, occupying three bays in the trestle structure, is 48 ft. in length and is made up of steel plate sides and bottom, suspended from the concrete bents. As indicated on Fig. 5, the coke bin is centrally located, discharging direct into the skip car, over McKee cascade type coke screens.

Eight ore and limestone bins of the Baker suspension type were installed, each bin being approximately 12 ft. in length and constructed of ⅜-in. steel plate sides and bottom. The bins are provided with a continuous line of segmental type gates arranged for convenient operation from the scale car platform, and discharge into an 80 cu. ft. capacity scale car, which delivers the material to the skip pit. The scale car is of heavy construction, is electrically driven and equipped with air brakes.

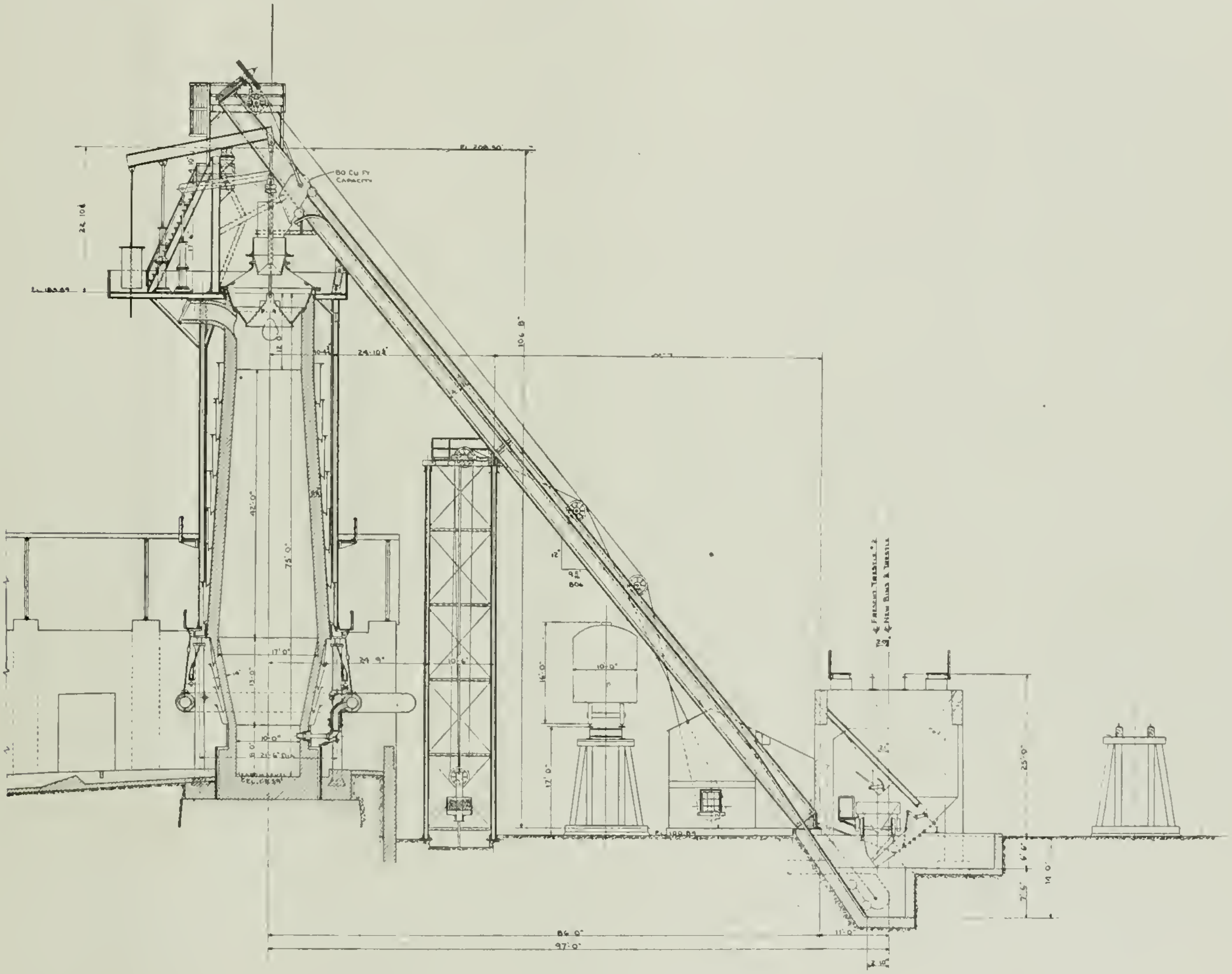


Fig. 5—Section through the furnace.

The charge is carried to the furnace top in a skip car of 80 cu. ft. capacity, traveling on a single track skip bridge, which is provided with deck plates to prevent materials falling through to the ground. The skip is supported by a hinged leg from the furnace top platform and rests on the old hoist tower as an additional means of support. At the upper end of the skip bridge is provided a sheave platform with a 5-ft. diameter cast iron sheave for accommodating the 1-in. plow steel skip hoist cable, idler sheaves being placed at different points along the bridge.

A 12x12-in. single drum Otis hoisting engine was installed in a brick hoist engine house, having concrete foundations and steel roof supports.

No changes were made to the existing furnace shell, a new top ring casting being furnished to fit the present design. There was also provided a new large bell hopper, made of cast steel in four sections, and a new gas seal of ½-in. steel plate with cast steel bottom ring and cast iron top ring. The gas seal contains two hinge type hanholes, 30 in. in diameter, for removal or inspection of the small bell.

On top of the gas seal is mounted a McKee revolving stock distributor, consisting of small bell, bell hopper, small bell rod, ball races and drive mechanism. For operation of the revolving distributor a 7½-hp. Crocker-Wheeler, 220-volt, dc. motor was supplied, the motor being located on the furnace top platform and enclosed with proper housing. Control of the distributor is accomplished automatically by means of a limit switch connected to the hoist engine drum.

The furnace charge is discharged from the skip car into a receiving hopper constructed of ⅜-in. steel plate and provided with ½-in. wearing plates. Directly beneath this receiving hopper is a revolving hopper, which is of ¾-in. steel plate and which attaches to and revolves with the distributor.

An entirely new furnace top platform with 5/16-in. floor plates was furnished and erected. Supported on the top platform is a hand operated jib crane suitably designed for raising and lowering the large bell, hopper and other equipment. The operation of the large and small bells is accomplished by means of a bell rig mounted on the furnace top platform and consisting of 14-in. and 10-in steam cylinders, bell beams, counterweights, bearings and shafts. A modern test rod mechanism and indicator were also installed.

Stairs and walkways have been erected wherever necessary to give access for inspection or repairs, and guard railings and other safety features were installed in accordance with the State Code.

In the cast house, new iron and cinder runners were provided. The iron pours into a 50-ton Pugh type hot metal car and is then transported to the pig casting machine.

The single strand pig machine was furnished by the Pittsburgh Coal Washer Company, the supporting and housing structure for same being designed and erected by Arthur G. McKee & Company. The machine has a speed of approximately 20 feet per minute, carrying one pig mold per foot of chain, each mold casting a pig weighing from 100 to 125 lbs.

As the balance of the existing plant equipment was found adequate for operation with the improvements above described, no further changes were made, with the exception of the hot blast stove fittings. Each stove was equipped with complete new hot blast valve, chimney valve and air relief valve, all of McKee standard design.

Although existing conditions have made it inadvisable to operate the plant since completion of the reconstruction work, arrangements have been made to blow the furnace in at an early date.

The Structure of Coke

Modifications Described Which Occur in the Cell Structure of Coke from the Beginning of the Process to the Finish.

By H. D. GREENWOOD and J. W. COBB

VARIOUS views have been taken from time to time of the processes involved in the formation and structure of coke. These have been mainly concerned with the problem of the initial cell formation as distinct from any succeeding structural changes. A brief summary will not be out of place.

Coke is generally regarded as formed by the liquefying of easily fusible constituents of the coal followed by decomposition, the formation of cells by the inflating effect of escaping gas, and gradual solidification. Wedding attributed the formation of coke to the decomposition of the richer gaseous hydrocarbons. According to Lewes ("Carbonization of Coal") the heat passing gradually from layer to layer of the charge drives before it the heavy tars; these are alternately deposited and redistilled with some decomposition, which becomes responsible for the formation of coke.

S. R. Illingworth develops the view that the formation of coke and its resulting structure are dependent upon the volume and rate of evolution of gas given off during the period in which the material is in a plastic condition.

It is known that coking coals undergo a partial liquefication at about 450 deg. C. The plasticity may safely be attributed to the melting of certain constituents of coal and their impregnation of the mass. The gases evolved by the decomposition of these and other constituents are responsible for the formation of pores or cells in a mass which gradually stiffens to rigidity as the decomposition proceeds. Further evolution of gas occurs as the temperature rises, which modifies the cell structure without altering its fundamental character, although the modifications have their own technical importance.

In the following paper we have attempted to trace these later changes in the coke from the newly formed cell structure to the final formation of high-temperature coke.

To this end cokes were prepared from the same coal in the laboratory at three different temperatures, 550 deg. C., 850 deg. C. and 1100 deg. C., and the cokes were examined. These may be taken respectively to represent approximately the products of low-temperature carbonization (550 deg. C.), medium-temperature carbonization as in horizontal gas retorts (850 deg. C.), and high-temperature carbonization as in coke ovens making metallurgical coke (1100 deg. C.) A parallel examination was made of a commercial sample of hard by-product coke for comparison with the 1100 deg, C. experimental coke.

Preparation of Coke

The same coal was used in the preparation of these cokes, these having the following composition: Carbon 77.36 per cent, hydrogen 5.66 per cent, sulphur 1.65 per cent, nitrogen 1.34 per cent, oxygen 10.22 per cent, ash 3.77 per cent. Volatile matter 37.3 per cent (American crucible method, 1899). It was the Nottinghamshire (New Hucknall) gas-coal used by Hollings and Cobb in their study of thermal phenomena in carbonization (Trans. Inst, Gas Eng., 1914, 225-277). The coal was coked in pieces of pea size in a large fireclay crucible holding about 400 grams, and fitted with a lid, through which a hole was bored for the insertion of a thermocouple. The couple was protected by a silica sheath, and the junction maintained about one inch from the bottom of the crucible. Before coking the lid was cemented to the crucible.

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*Abstract of paper read before the Society of the Chemical Industry.

Each coal was raised to the desired temperature in about three hours and maintained at that temperature for another three hours—six hours altogether. Cooling in situ followed.

After cooling, the coke was extracted and ground to pass between one-third-inch and one-quarter-inch mesh sieves, thus giving fragments of an average diameter of 3 mm., the coke within one-half inch of the crucible wall being discarded.

The by-product coke was obtained from the quenching bench of an Otto by-product battery (Robin Hood Colliery, Yorkshire).

The changes in weight, specific gravity, volume and porosity undergone in the carbonization process were then determined.

Determination of Specific Gravity and Porosity of the Coke

The terms "real" and "apparent" are generally used with reference to the specific gravity of the material composing the walls of the coke cells, and of this material together with the cells, respectively. We shall deal with three different specific gravities for any one sample of coke. In place of "real specific gravity," the term "specific gravity of coke material" will be used; in place of "apparent specific gravity" the term "specific gravity of material and all cells," the third specific gravity being that of the "material and closed cells."

Determination of the Specific Gravity of the Coke Material

The coke was ground to pass a sieve of 60 meshes to the inch, and about 1 g. of this powder was exhausted under water in a specific gravity bottle heated on a water bath. The exhaustion was continued for about three hours, then the bottle was disconnected and the specific gravity determined in the usual manner. On filling the bottle in the ordinary way after exhaustion, flakes of coke floating on the surface are lost, thus introducing an appreciable error. To avoid this, the exhaustion was carried out with the stopper in situ, and when complete the bottle was completely exhausted and the rubber connecting tube opened under water; in this way the bottle could be filled without loss of material. A catch bulb was usually placed above the bottle to prevent any loss by spirting.

The same method was used to determine the specific gravity of the "material + closed cells," with the exception that fragments of coke were used in place of the powdered material.

The values so obtained were somewhat lower than with the powdered coke, owing to the presence of "closed cells," into which the water could not penetrate.

Specific Gravity of Material + All Cells

This determination was carried out in a volumenometer (Anderson, J., 1896, 20) which consists essentially of a wide glass tube fitted with a ground glass stopper terminating in a glass stopcock, the other end being connected by rubber tubing with a burette. The tube is filled with water and a known weight of coke introduced, the coke being in fragments of the largest size which can enter the tube.

From the volume of water displaced, measured on the burette, the specific gravity of the coke fragments can be determined. The accuracy of the determination is dependent primarily upon the nonpenetration of the water into the coke cells, and upon any small volume of gas expelled from pores by the water being the same before and after expulsion. With the 850 deg. C. coke, considerable volumes of gas were evolved on immersion in water, but by taking readings quickly, or, better, by replacing the water by mercury, consistent results were obtained.

From the specific gravities thus determined, it is possible to calculate the porosity of the coke.

Let specific gravity of the coke material = A.

Let specific gravity of the coke material + all cells = B.

Let specific gravity of the coke material + closed cells = C.

Then % total porosity (by volume) $= 100(1-B/A$ (1)

Then % closed pores (by volume) $\frac{100B\ (A-C)}{A.C.} =$ (2)

By subtracting (2) from (1) we are left with the percentage of "open pores." The results thus obtained are collected in Table I.

Table I—Changes in Porosity and Specific Gravity in Coking

Temp of coking. Deg. C.	Sp. gr. of coke material	Sp. gr. of material and all pores	Sp. gr. of material + closed pores	Per cent open pores	Per cent closed pores	Per cent total porosty
Original coal	1.270	1.270	.....	.....	.....	.....
550° C.	1.591	0.879	1.446	39.2	5.5	44.7
850° C.	1.870	0.888	1.563	43.17	9.33	52.5
1100° C.	1.870	1.014	1.631	37.85	7.95	45.8
By-Product (hard)	1.880	1.012	1.720	40.6	5.0	45.6

The results obtained by Anderson, given in the paper already quoted, are similar to those shown in Table I, and it is of interest to note the difference which he obtained when using fragments of coke as compared with powdered coke for exhaustion in the specific gravity bottle.

Specific gravty of—	1.	2.	3.
(a) fragments of coke	1.623	1.666	1.730
(b) Powdered coke	1.832	1.850	1.880

These differences, although not strictly comparable with ours, are of the same order of magnitude.

It will be seen from Table I that the "coke material" had attained a density at 850 deg. C. or by-product "coke material."

From these results we have calculated the changes in volume and specific gravity which the coal underwent on coking, and which have a bearing on the structure of the resulting coke. Thus the figures in Table II indicate the changes in volume, etc., undergone by 100 g. of coal on heating to 1100 deg. C. in three stages.

When a coking coal is heated to about 400 deg. C. it undergoes a partial liquefication, due doubtless to the presence of substances melting at about that temperature. Further heating causes the decomposition of these and other substances, the mass becoming decreasingly plastic. Bubbles of gas force their way through the semi-plastic material and form cells or pores which permanently retain their shape when the mass has attained a certain degree of rigidity. In the further decomposition, the plasticity is so small that the evolution of gas causes no such change in the material, which remains as a porous mass—coke.

The formation of the cells is accompanied by a swelling of the mass. It is probable that between 450 deg. and 500 deg. C. the swelling of the coal is considerably greater than would appear from Table II, the semi-plastic stage having been passed and the general contraction begun below 550 deg. C.

The porous material formed consists of sealed and unsealed pores with walls of semi-carbonized material.

Table II—Changes in Weight and Volume in Coking

	Wt. g	Vol. of coke (or coal) + all pores. c.c.	Vol of coke (or coal) material c.c.	Total vol of pores c.c	Change n vol. at each stage as per cent of original coal volume.
Original coal....	100	78.8	78.8	....)	Inc 2.8
Coked at 550– C.	71	81.0	44.6	36.4)	
Coked at 850° C.	64	72.0	34.2	39.8	dec. 11.4
Coked at 1100° C	63	63.0	33.7	29.3	dec. 11.4
Total change from 15° to 1100° C.	–37	–15.8	–45.1	+29.3	nett dec. 20.0

The specific gravity of the cell walls is greater than that of the original coal, but the specific gravity of the mass as a whole is less than that of the coal.

There is some gain in total volume in spite of the great loss of weight. The cell structure is developed at 550 deg C., but further heating causes considerable changes in the coke material, with accompanying changes in the porosity of the mass.

Heating at 850 deg. C. results in a further evolution of gas, entailing a decrease in the mass and volume of the coke material. The mass as a whole shrinks to the extent of 11.4 per cent of the volume of the original coal, but owing to the loss in weight and increased density of the coke material, the porosity increases by 7 per cent, giving the maximum value observed, 52.5 per cent. The effect of this change is to give a coke with larger cells, the walls of which are, however, composed of denser and harder material.

The effect of the increase in density of the material (from 1.59 to 1.87) appears to overbalance the reduction in strength arising from the enlargement of the cells, since this coke is substantially stronger than the 550 deg. C. coke.

Between 850 deg and 1100 deg. C. a further shrinkage of 11.4 per cent takes place in the mass as a whole, but the process is otherwise not the same as in the previous stage. The loss if weight is only 1 per cent, the specific gravity of the coke material is unchanged, but the porosity falls again to 45.8 per cent.

A considerable thickening of the cell walls must have taken place, and is probably the principal cause of the accession of strength in this stage, although the deposition of bright carbon on the cell-walls resulting from the decomposition of methane in contact with them, is also likely to play its part. The coke at 1100 deg. C. is, therefore, made up of smaller cells than at 850 deg. C. with thicker walls; it is a stronger material.

The values for the various specific gravities and porosities of the by-product coke are very similar to those obtained for the 1100 deg. C. laboratory coke.

Summarizing, we can divide the formation of high-temperature coke into three stages:

1. The first stage up to 550 deg. C. is constituted by the initial cell formation, these cells having relatively thick walls of soft material of low specific gravity, the process being accompanied by a swelling of the charge.
2. Between 550 deg. and 850 deg. C. the mass as a whole shrinks and an increase in specific gravity of the coke material ensues, the resulting coke having thinner but stronger walls and the porosity reaching a maximum.
3. In the last stage the predominant factor is a further large contraction of the mass as a whole, the coke material undergoing no appreciable increase in specific gravity. We are thus left with a strong coke, constituted of small pores with relatively thick walls. At no stage in coking to 1100 deg. C. does the material approximate to the specific gravity of graphite, 2.3.

We have followed the process in a fairly typical gas coal, but believe that its essential features would be reproduced in the behavior of coking coals generally.

It may be mentioned that the swelling of the coal in the first stages of carbonization is well known to cause difficulties in withdrawing coke made at low temperatures, and in promoting sticking at the top of the charge in continuous vertical retorts and gas producers, particularly when fitted with a bell.

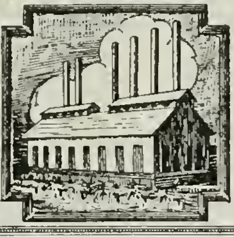
ISSUES BULLETIN ON STUDY OF ALLOY STEELS

Studies in the experimental production of certain alloy steels are discussed by H. W. Gillet, chief alloy chemist and E. L. Mack, assistant alloy chemist, in a bulletin which has just been published by the United States bureau of mines.

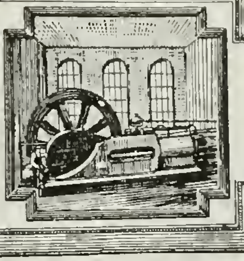
The production of small heats of alloy steels on an experimental scale often is desirable in beginning the study of new alloy steels before large amounts of expensive alloys are used in heats of commercial size. Such small heats sometimes can be made up at crucible steel plants, but few crucible steel makers care to undertake experimental heats for other firms. Small electric furnaces offer some advantages over crucible furnaces for experimental work, and various types ofsuch furnaces are being successfully used by different firms for such work. The bureau of mines recently made up experimental heats of alloy steel for the army and the navy. The steels for the army were desired for work on gun erosion, especially as regards the effect of nitrogen on steel. The request from the war department for this experimental work was made during the course of the world war and followed the receipt of information from a creditable source that Germany was using uranium steel in the liners of some high-power naval guns. It was stated that uranium stiffens steel at high temperatures, and raises the softening point some 200 deg. C. so that gun erosion is reduced. The fact that the German guns retained accuracy of fire at the end of the Jutland naval engagement was ascribed to the uranium-steel gun liners.

BORON AS A STEEL ALLOY

Experimental work performed by the United States Bureau of Mines indicates that the use of boron as an alloy confers marked hardness on steel. If the other physical properties of the boron steels are good enough to be applicable to commercial use, their remarkable plasticity at temperatures below the melting points of ordinary steels might make it possible to utilize this characteristic.



STEAM POWER DEPARTMENT

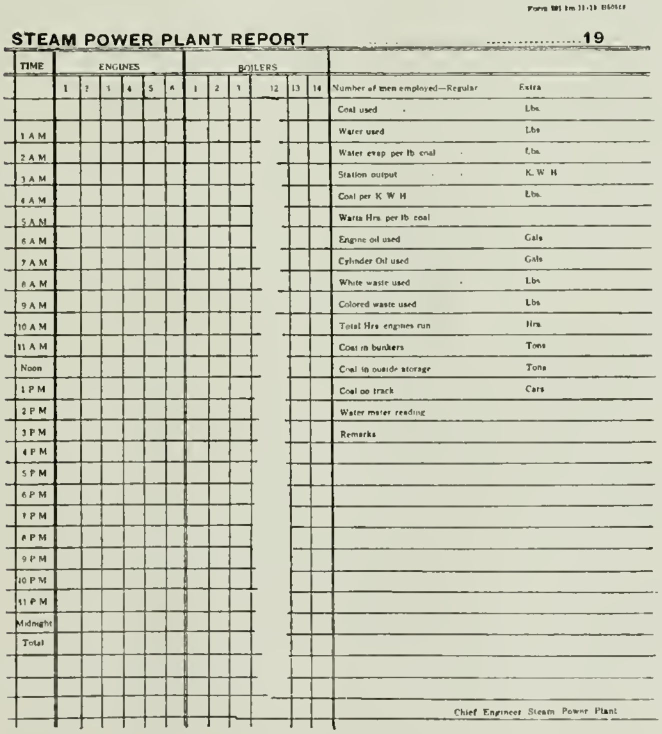


Steel Works Power Plant Management

A Continuation of the Series on Power Plant Accounting and Recording, Giving Performance Logs—Manner of Keeping Performance Records Has Changed During Last Few Years.

By ROBERT JUNE, Associate Member A. S. M E.

THE keeping of performance records in the power plant is a rule rather than the exception even in small plants. In this respect there has been considerable change in practice during the past five or six years. When both coal and labor were cheap there was less incentive to keeping records. Today it is not a question of whether records shall be kept, but rather of what form these records shall take in order that they may be of the greatest practical value.



Form 101 1m 11-21 [illegible]

STEAM POWER PLANT REPORT 19

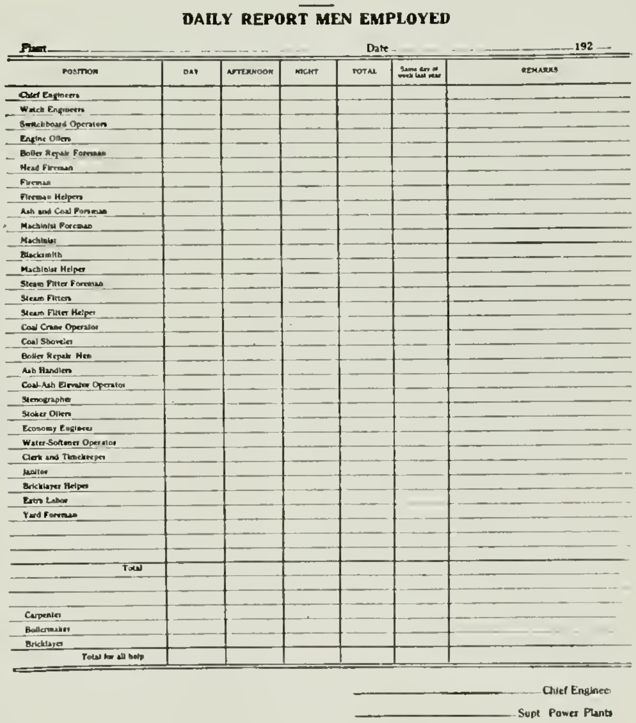
TIME	ENGINES						BOILERS							
	1	2	3	4	5	6	1	2	3	12	13	14	Number of men employed—Regular	Extra
													Coal used	Lbs.
1 A M													Water used	Lbs.
2 A M													Water evap per lb coal	Lbs.
3 A M													Station output	K. W. H.
4 A M													Coal per K W H	Lbs.
5 A M													Watts Hrs. per lb coal	
6 A M													Engine oil used	Gals
7 A M													Cylinder Oil used	Gals
8 A M													White waste used	Lbs
9 A M													Colored waste used	Lbs
10 A M													Total Hrs. engines run	Hrs.
11 A M													Coal in bunkers	Tons
Noon													Coal in outside storage	Tons
1 P M													Coal on track	Cars
2 P M													Water meter reading	
3 P M													Remarks	
4 P M														
5 P M														
6 P M														
7 P M														
8 P M														
9 P M														
10 P M														
11 P M														
Midnight														
Total														

Chief Engineer Steam Power Plant

Fig. 1.

It should be recognized, first of all, that the compilation of unnecessary data is to be avoided. By unnecessary data, we mean information relating to conditions which cannot be changed. The second consideration is that all records compiled should at all times be available to the men who control the figures which go to make up the records. That is to say, the boiler room superintendent should, at all times, know the amount of coal which he is using and he should have before him the records of previous performances for the sake of comparison.

As a matter of fact, records should be kept by the men who are actually doing the work, and not by outside clerical help.



DAILY REPORT MEN EMPLOYED

Plant ________________ Date ________________ 192__

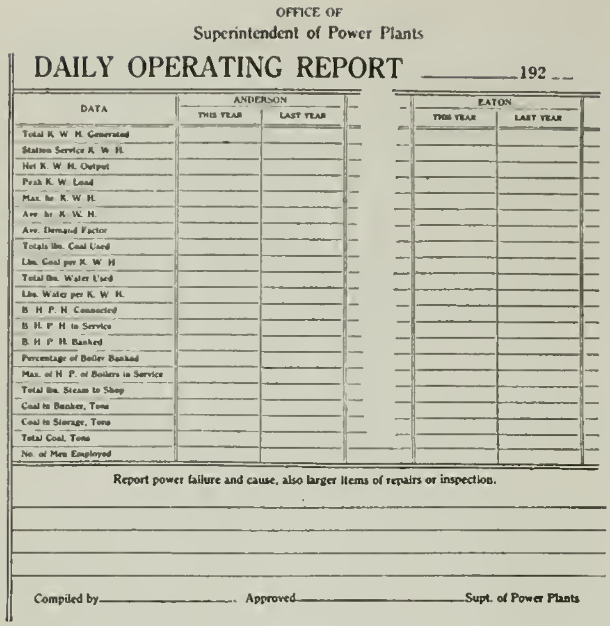
POSITION	DAY	AFTERNOON	NIGHT	TOTAL	Same day of week last year	REMARKS
Chief Engineers						
Watch Engineers						
Switchboard Operators						
Engine Oilers						
Boiler Repair Foreman						
Head Fireman						
Fireman						
Fireman Helpers						
Ash and Coal Foreman						
Machinist Foreman						
Machinist						
Blacksmith						
Machinist Helper						
Steam Fitter Foreman						
Steam Fitters						
Steam Fitter Helper						
Coal Crane Operator						
Coal Shoveler						
Boiler Repair Men						
Ash Handlers						
Coal-Ash Elevator Operator						
Stenographer						
Stoker Oilers						
Economy Engineer						
Water-Softener Operator						
Clerk and Timekeeper						
Janitor						
Bricklayer Helper						
Extra Labor						
Yard Foreman						
Total						
Carpenter						
Boilermaker						
Bricklayer						
Total for all help						

________________ Chief Engineer

________________ Supt Power Plants

Fig. 2.

The next point is that the operating men should not be bothered with dollars and cents computations. They cannot control the price of coal, or oil, or waste, or other materials, and they cannot control the price of labor. They have nothing to do with overhead or



OFFICE OF
Superintendent of Power Plants

DAILY OPERATING REPORT ________192__

DATA	ANDERSON This Year	ANDERSON Last Year	EATON This Year	EATON Last Year
Total K. W. H. Generated				
Station Service K. W. H.				
Net K. W. H. Output				
Peak K. W. Load				
Max. hr. K. W. H.				
Ave. hr. K. W. H.				
Ave. Demand Factor				
Totals lbs. Coal Used				
Lbs. Coal per K. W. H.				
Total lbs. Water Used				
Lbs. Water per K. W. H.				
B. H. P. H. Connected				
B. H. P. H. in Service				
B. H. P. H. Banked				
Percentage of Boiler Banked				
Max. of H. P. of Boilers in Service				
Total lbs. Steam to Shop				
Coal in Bunker, Tons				
Coal in Storage, Tons				
Total Coal, Tons				
No. of Men Employed				

Report power failure and cause, also larger items of repairs or inspection.

Compiled by________ Approved________Supt. of Power Plants

Fig. 3.

fixed charges, therefore do not confuse them by asking them to deal with monetary values, but let your records be kept and let them stand or fall upon their economical use of coal in tons, oil in gallons, waste in pounds, and labor in hours. Records kept by the men place at their disposal information which enables them to determine the performance, ability and economy of the equipment under their charge, so they can strive to better the output while decreasing the consumption of materials and labor.

Fig. 4—Daily operating log.

	12-8 A.M.	8-4 P.M.	4-12 P.M.
Feed water meter reading			
Lbs. water by F. W. meter			
No. of boiler blow downs			
Average inches per blow			
Lbs. water blow down			
Nos. of boilers filled			
Lbs. of water used for filling			
Lbs. water evaporated			
Average steam pressure			
Average F. W. temperature			
Factor of evaporation			
Average hp. developed			
Average hp. per boiler			
Average % rating			
Total lbs. coal fired			
Lbs. ash and refuse			
% ash and refuse			
No. combustion chambers cleaned			
% of moisture in coal			
Total lbs. dry coal fired			
Average CO_2			
Average CO			
Boiler efficiency % (total 24 hours only)			
Above standard % (total 24 hours only)			
Below standard % (total 24 hours only)			
Average Evap. actual			
Aver. Evap. Fr. and at 212 per lb. dry coal			
No. of fan operated			
........Foreman			

Reports to the management in which dollars and cents computations are involved should, in all cases, come through the accounting department where the costs of the various items can be readily and expertly set up. The amount of detail in the reports for the management and the frequency with which such reports are submitted depends upon the use to which they are to be put. Nothing unnecessary should be included. If the total output of the power plant and the total cost of fuel and wages are all that are desired, the report should be limited to these items.

If, however, reports are to go to an executive who exercises a direct hand in the supervision of the power plant, the reports should include such information as quality and quantity of coal, with special reference to the ash and moisture in the coal, the amount of oil, water and various boiler and engine room supplies used, and the separation of labor costs in the boiler and engine room help.

Fig. 5—Power house time card.

Location........................ Date.................., 19..

Nature of Work	Acct. No.	Hours	Rate	Amt.
Switching cars for roadway				
Cleaning yard				
Repairs to boilers, P. H. machinery, stokers, conveyors, etc.				
Engineer				
Oiler				
Water tender				
Fireman				
Boiler washing				
Unloading coal				
Miscellaneous P. H. labor				
Wheeling coal and ashes				
Cleaning fires				
Loading and delivering coal to substations				
Loading and delivering coal to station				
Work for Motive Power Dept.				
Totals				
Correct Signed				

Chief Engineer..............................

As the size of the plants increase it is desirable to include detail records of the number of hours of service rendered by each unit over daily, monthly and yearly periods, hourly flue gas temperature, barometric steam pressure and feed water temperature readings. By comparing such records a close check may be kept on plant efficiency and it is possible to determine the real value of expenditures for equipment so that future purchases may be made to best advantage.

It has been found practical dollars and cents value to keep constant records of such items as air pressure below grate, furnace draft, CO_2 in flue gas, as well as to watch smoke, to record tests of boilers, pumps and engines, keep close track of repairs and note the capacity of stokers, coal and ash-handling equipment, etc.

The personal equation and the problem of the individual plant will lead to placing emphasis on certain details of operation in one plant and placing this emphasis on other items in another plant. Log sheets should properly be individualized to meet the particular conditions in the plant where they are used, and it will be of interest to examine typical records which can be modified for individual use.

Fig. 1 shows the daily log sheet turned in by the chief engineer of each steam power plant operated by one well known company. It will be noted that this log deals only with quantities of material and hours of operation.

Fig. 2 is the report of men employed, used by the same company. This report is turned by the chief engineer to the office of the superintendent of power plants. In the latter office, computation of the cost of labor are made an dare added to the report so that the superintendent, at least, has the labor cost before him.

Fig. 3 is the combined operating report for all the

Fig. 6—Report of water softening and purifying system.

No.......................... Date...

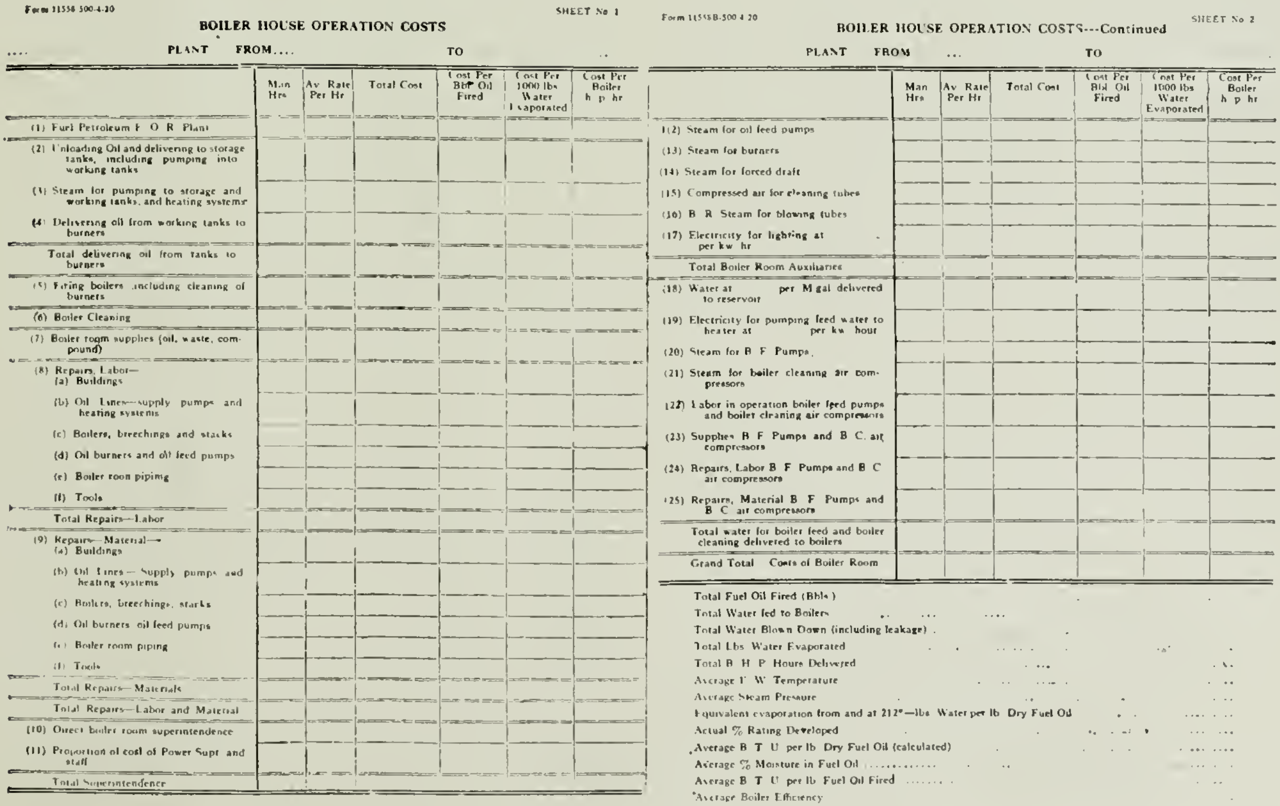
H—Hardness or Soap Test................................
C—Indicates Causticity or Phenolphthalein Test........
A—Indicates Alkalinity or Methyl Orange Test.. .....

Chemicals in Stock { Lime...................
Soda...................

Day	Date	Gallons Water Treated	Hours of Operation	Gallons Chemical Solution		Lbs. per 1,000 gal. Solution		Time of Charges	Temperature Treated Water	Raw Water		Treated Water		
				Lime	Soda	Lime	Soda			H	A	H	C	A
Sunday														
Monday														
Tuesday														
Wednesday														
Thursday														
Friday														
Saturday														

Remarks: ....
....
....
....

....*Chief Engineer.*



Form 11558 500-4-20 SHEET No 1

BOILER HOUSE OPERATION COSTS

.... PLANT FROM.... TO ..

	Man Hrs	Av Rate Per Hr	Total Cost	Cost Per Bbl Oil Fired	Cost Per 1000 lbs Water Evaporated	Cost Per Boiler h p hr
(1) Fuel Petroleum F O R Plant						
(2) Unloading Oil and delivering to storage tanks, including pumping into working tanks						
(3) Steam for pumping to storage and working tanks, and heating systems						
(4) Delivering oil from working tanks to burners						
Total delivering oil from tanks to burners						
(5) Firing boilers including cleaning of burners						
(6) Boiler Cleaning						
(7) Boiler room supplies (oil, waste, compound)						
(8) Repairs, Labor— (a) Buildings						
(b) Oil Lines—supply pumps and heating systems						
(c) Boilers, breechings and stacks						
(d) Oil burners and oil feed pumps						
(e) Boiler room piping						
(f) Tools						
Total Repairs—Labor						
(9) Repairs—Material— (a) Buildings						
(b) Oil Lines—Supply pumps and heating systems						
(c) Boilers, breechings, stacks						
(d) Oil burners oil feed pumps						
(e) Boiler room piping						
(f) Tools						
Total Repairs—Materials						
Total Repairs—Labor and Material						
(10) Direct boiler room superintendence						
(11) Proportion of cost of Power Supt and staff						
Total Superintendence						

Form 11558-500 4 20 SHEET No 2

BOILER HOUSE OPERATION COSTS---Continued

PLANT FROM ... TO

	Man Hrs	Av Rate Per Hr	Total Cost	Cost Per Bbl Oil Fired	Cost Per 1000 lbs Water Evaporated	Cost Per Boiler h p hr
(12) Steam for oil feed pumps						
(13) Steam for burners						
(14) Steam for forced draft						
(15) Compressed air for cleaning tubes						
(16) B R Steam for blowing tubes						
(17) Electricity for lighting at per kw hr						
Total Boiler Room Auxiliaries						
(18) Water at per M gal delivered to reservoir						
(19) Electricity for pumping feed water to heater at per kw hour						
(20) Steam for B F Pumps						
(21) Steam for boiler cleaning air compressors						
(22) Labor in operation boiler feed pumps and boiler cleaning air compressors						
(23) Supplies B F Pumps and B C air compressors						
(24) Repairs, Labor B F Pumps and B C air compressors						
(25) Repairs, Material B F Pumps and B C air compressors						
Total water for boiler feed and boiler cleaning delivered to boilers						
Grand Total Costs of Boiler Room						

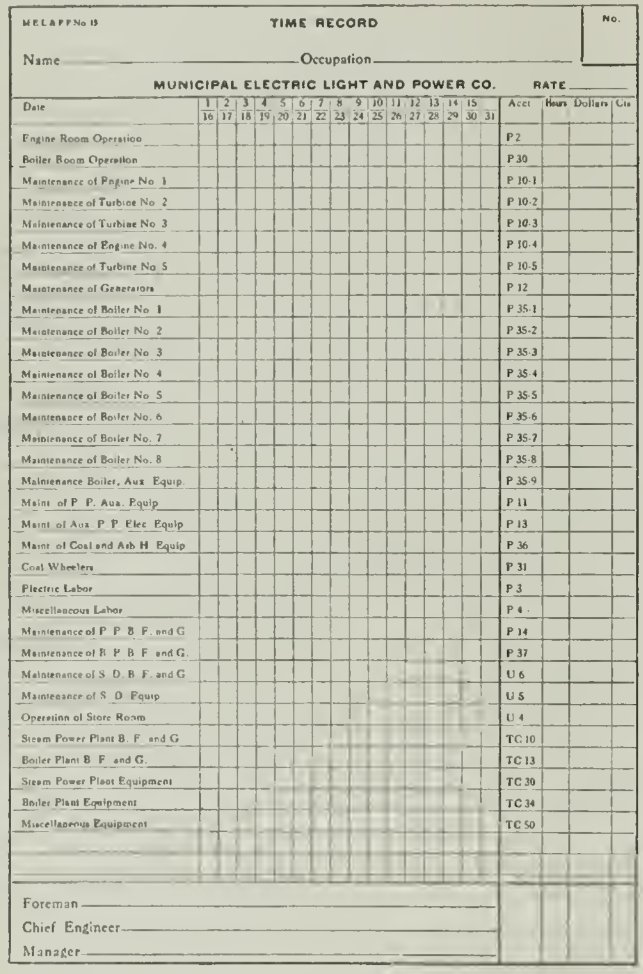
Total Fuel Oil Fired (Bbls)
Total Water fed to Boilers
Total Water Blown Down (including leakage)
Total Lbs Water Evaporated
Total B H P Hours Delivered
Average F W Temperature
Average Steam Pressure
Equivalent evaporation from and at 212°—lbs Water per lb Dry Fuel Oil
Actual % Rating Developed
Average B T U per lb Dry Fuel Oil (calculated)
Average % Moisture in Fuel Oil
Average B T U per lb Fuel Oil Fired
Average Boiler Efficiency

Fig. 7.

power plants and is made up from the logs shown in Figs. 1 and 2, for all plants. The logs just referred to deal with the units of time and material, and the unit of output. A more intimate record of operating conditions, however, is desirable. This is to be obtained by making a record of such data as the following:

In conjunction with the use of the log in Fig. 4, the chief engineer will also want detail record of the time put in by different men on different jobs. This record can be in the form shown in Fig. 5.

In this case the chief engineer will make this form out in triplicate, filling in only the hour's column. The office of the superintendent of power stations will fill in rates and amounts, and send a copy of each to the accounting department, who will set up the charges. By constant reference to these time cards, the chief engineer will have a ready comparison between the performance on any given date and the average time required for similar work.



MELAPP No 13 TIME RECORD No.

Name ____ Occupation ____

MUNICIPAL ELECTRIC LIGHT AND POWER CO. RATE ____

Date	1 16	2 17	3 18	4 19	5 20	6 21	7 22	8 23	9 24	10 25	11 26	12 27	13 28	14 29	15 30	31	Acct	Hours	Dollars	Cts
Engine Room Operation																	P 2			
Boiler Room Operation																	P 30			
Maintenance of Engine No 1																	P 10-1			
Maintenance of Turbine No 2																	P 10-2			
Maintenance of Turbine No 3																	P 10-3			
Maintenance of Engine No. 4																	P 10-4			
Maintenance of Turbine No 5																	P 10-5			
Maintenance of Generators																	P 12			
Maintenance of Boiler No 1																	P 35-1			
Maintenance of Boiler No 2																	P 35-2			
Maintenance of Boiler No 3																	P 35-3			
Maintenance of Boiler No 4																	P 35-4			
Maintenance of Boiler No 5																	P 35-5			
Maintenance of Boiler No. 6																	P 35-6			
Maintenance of Boiler No. 7																	P 35-7			
Maintenance of Boiler No. 8																	P 35-8			
Maintenance Boiler, Aux Equip.																	P 35-9			
Maint of P P. Aux. Equip																	P 11			
Maint of Aux P P Elec Equip																	P 13			
Maint of Coal and Ash H Equip																	P 36			
Coal Wheelers																	P 31			
Electric Labor																	P 3			
Miscellaneous Labor																	P 4			
Maintenance of P P B F and G																	P 14			
Maintenance of B P B F and G.																	P 37			
Maintenance of S D. B F. and G																	U 6			
Maintenance of S D Equip																	U 5			
Operation of Store Room																	U 4			
Steam Power Plant B. F and G																	TC 10			
Boiler Plant B F and G.																	TC 13			
Steam Power Plant Equipment																	TC 30			
Boiler Plant Equipment																	TC 34			
Miscellaneous Equipment																	TC 50			

Foreman ____

Chief Engineer ____

Manager ____

Fig. 8.

Fig. 6 is a report on the water softening and purifying systems. Reports of this character should not only be used for water softening apparatus, but for any other special equipment.

Fig. 7 is a form for weekly, monthly and yearly reports of boiler house operating costs. This chart was developed by one of the keenest engineering organizations in the country and is in constant use for recording costs in a large number of power plants under its supervision.

Fig. 8 is the semi-monthly time record employed by another operating company with a municipal power plant. This record shows the maintenance cost of all important units of equipment.

Fig. 9 is a daily graphic chart kept in the power superintendent's office of the operating company referred to above. This chart is plotted daily on cross section of cloth. At the end of every month, the monthly average curve is drawn on the chart in red. This graphic record is always available, and when desired the charts for a year or more back may be tacked up on the bulletin board as an object lesson to all operating men.

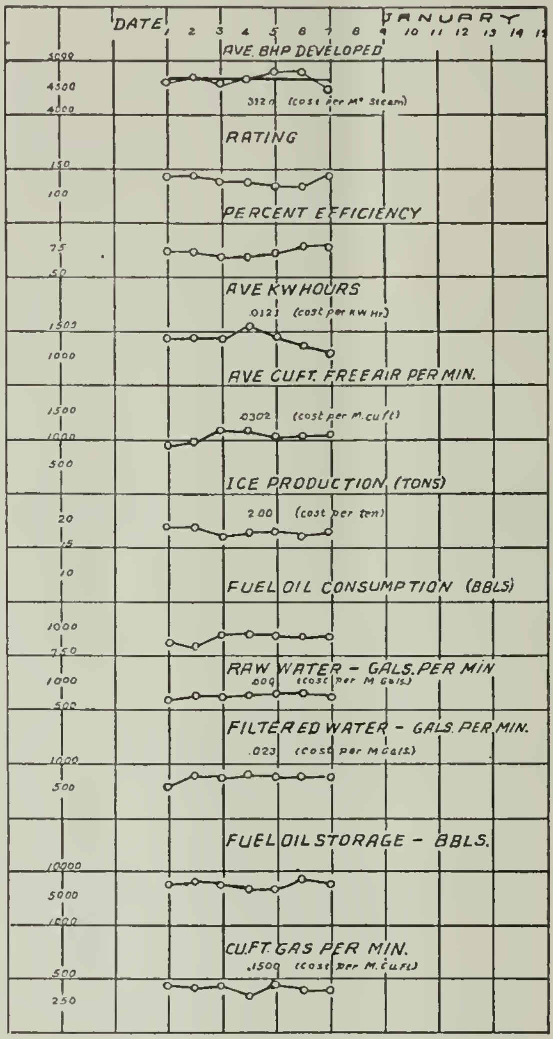


Fig. 9.

As stated above, the performance log should be drawn up to meet the individual conditions obtaining in each plant. There is one danger in doing this, however, in that there is frequently a temptation to include too much irrelevant data. The things with which everyone should be concerned are those factors in operation which have an important bearing upon the total cost of production and which can, in some measure, be controlled.

It is perfectly useless for operating men to make records covering factors which cannot be controlled. Let the operating men center their efforts on such principle points as coal consumption per kw. hour and men per hour required for various operations, and improvements in operating conditions will result.

Oil and Coal Mixed Used for Fuel

The United States Bureau of Mines Suggests a Mixture of Oil and Coal, Which Bears a Relationship to the Trent Process, as an Emergency Fuel.

As an emergency fuel, a mixture of fuel oil with fine coal in as large proportions as the coal will absorb and hold is suggested by the United States Bureau of Mines to steam coal users and gas manufacturers to augment their fuel supply during the present shortage.

Slack coal that has a high percentage through an 8-mesh screen, or which may be crushed to sizes of ⅛ inch or less, will take up in oil from 30 to 40 per cent of its own weight and make a fuel high in calorific value. Coarse slack coal, however, as judged by a representative sample from the Pittsburgh market, will absorb oil to only 3 to 10 per cent of its own weight, which would give a fuel having only about 4 to 15 per cent increased heating value. The finer the size of the coal, therefore, the larger is the amount of oil which will be held. Tests made by the Bureau of Mines at its Pittsburgh experiment station indicate that the mixture can be made with either bituminous slack or anthracite culm.

This method bears a relationship to the Trent process of purifying coal by fine grinding and amalgamation with oil, now in operation at a plant at Alexandria, Va., which has demonstrated the success of a combination of oil and coal for steam-making, gas manufacturing and other fuel purposes. The present emergency proposal does not contemplate the cleaning process, but involves merely the simple mixing by shovel or concrete mixer. The Trent Corporation has volunteered to assist the Government in advising in the use or application of oil-coal mixtures, and to waive, during this emergency, any claim of infringement of its process which may or may not be involved by the simple mixing of fuel oil and coal, without reference to cleaning.

An oil refinery at Baltimore, it is reported, mixed by shovel a ton of heavy Mexican fuel oil with two or three tons of Western Maryland slack coal, and used it successfully in a switch engine. At the experiment station of the Bureau of Mines at Pittsburgh it was found that mixtures containing one ton of Mexican fuel oil and four to five tons of Pittsburgh slack coal could be used in a hand-fired furnace.

In using oil-coal mixtures, the fire will smoke badly after firing, or while breaking up the coke bed from time to time. From such limited amount of testing as has been done by the Bureau of Mines, it was shown that careful firing is required to prevent continuous smoking. Experimenting must be done in each case to determine the best method of firing.

Chain grates and certain other automatic stokers are probably well adapted to handle the oil-fuel mixture if the bin and feeding devices are suitable. Oil-fuel mixtures will not fire spontaneously, but undoubtedly care should be exercised to ventilate bins where external heat may tend to drive off lighter gases, although the fuel oil which is on the market has had the lighter oils distilled from it.

Anthracite culm dust which would sift through ordinary grate bars can be used successfully when mixed with the oil, as the oil causes it to adhere and the oil residue cokes as soon as heated. Oil and anthracite mixtures are not smokeless with hand firing, the Bureau of Mines tests indicate.

This simple mixture of fuel oil and coal is proposed by the Bureau of Mines merely as a temporary measure. While under conditions of normal fuel supply such a mixture probably would not prove satisfactory unless it involved the cleaning feature embraced in the Trent process. In places where fuel oil is available it can be used to piece out a poor coal supply without the changes in equipment necessary to convert boilers to oil burning.

NEW OVENS TO BE BUILT BY KOPPERS

The Koppers Company has been awarded a contract to build 366 by-product coke ovens of its new design for the Carnegie Steel Company at Clairton, Pa., together with a by-product plant and benzol plant. These ovens will be of the combination type, so arranged that they may be heated with producer gas or blast furnace gas, releasing all of the coke oven gas for use in the mills.

The ovens to be built at Clairton are of a design recently perfected by the Koppers Company and represent a great improvement over any previous development in the by-produce coke industry, either in this country or abroad. Improved quality of coke produced, making possible more economical blast furnace practice by reducing the consumption of coke per ton of iron produced, a faster coking time giving a greater capacity per oven per day, and stronger construction are the principal advantages of this new design.

This addition will increase the carbonizing capacity of the Clairton by-product coke plant by 8,500 tons of coal per day, and when completed, will bring the carbonizing capacity of this plant up to a total of 21,500 tons of coal per day. The present by-product coke plant at Clairton, already the largest of its kind in the world, furnishes coke and gas necessary to operate the blast furnaces and steel mills of the Carnegie Steel Company in the Pittsburgh district. The original installation, consisting of 10 batteries of 64 ovens each, was completed in 1917 and during 1918 two additional batteries of 64 ovens each were installed. This last addition of 366 ovens brings the total up to 1,134, all of which will have been designed and built by the Koppers Company.

Joseph Becker, of Pittsburgh, consulting engineer of the Koppers Company, is the inventor of this new oven. An experimental battery of ovens of this design has been in operation at the Koppers Company's plant in Chicago for the past year, and it is believed that the performance of this experimental plant was largely instrumental in deciding the Carnegie Steel Company to build this new type of oven.

Review of a German Book on Open Hearths

Hubert Hermanns' Book, Entitled "Das Moderne Siemens-Martinstahlwerk," Interestingly Reviewed—Recently Published in Germany.

Review by **WALTER de FRIES**

THE purpose of this book, as Mr. Hermanns points out in the preface, is a description of open hearth plant equipment, with which he aims to fill in a space left in the literature pertaining to open hearth practice. There are a number of authentic books on the theory and practice of the open hearth process, while all knowledge of the necessary equipment beyond the furnace construction proper usually has to be gathered from trade publications, catalogues and magazine articles. In this respect the book is similar in many ways to the volume published two years ago by the Wellmann, Seaver, Morgan Company, entitled the "Open Hearth," with that distinction, however, that it is a survey of equipment as designed by the several German firms specializing in this line rather than a catalogue illustrating equipment of one particular company only, as in the case of the American book referred to. It is, therefore, of decidedly higher value, giving the seeker for knowledge at least a very good start and introduction, accompanied by an explaining text evidently intended for student consumption principally. There are a number of references and reprints from articles describing American plants, with some rather startling statements, such as, for instance, that the plant of the Weirton Steel Company is equipped with stationary 200-ton furnaces, but in general, one may say that Mr. Hermanns has evidently carefully studied the blast furnace and steel plant during the last few years and incorporated everything that may be of interest to his German readers in his book.

From the American viewpoint his book is interesting as evidently describing modern German practice. There is little, however, which could be copied—as is—though there are a few constructions which are conspicuous by their absence in American plants. Chief among these are electrically operated scrap-bundling machines, two types of which are illustrated; an electrically operated door-hoisting mechanism with one single motor drive for a series of doors, and the so-called "Heinzelmann Entlader" ("Unloader") for unloading coal, etc., from flat cars. The revolving turret type charging machine, evidently in general use abroad, may yet find some friends in this country, considering that it eliminates entirely the movement of the charge by rail and locomotive.

Interesting is the further description of open hearth port construction abroad, though it can hardly be recommended to follow the "rules of thumb" given by the writer for their design. The Gary works of the Steel Corporation will undoubtedly be interested to learn that their output of three heats per day in their 70-ton furnaces, with a total day production of 210 tons, is readily equalled by standard German 40-ton furnaces in hot metal practice. The superiority of the German furnace the writer attributes to the difference in height of the bath, which is, as he states, as high as 24 in. in the States, with a maximum of 12 in., now rarely exceeded in Germany, particularly. This is an interesting criticism, and the logic of the German pan design, as compared with our own, seems to merit investigation at least.

Of further interest is a description of a one-way flame type open hearth designed by Corsalli, stationary in structure and similar in principle to the 400-ton tilting furnace designed by Talbot, which was described in this journal not so long ago.

The chapter dealing with producers is an elaboration of an article by the same author, which appeared in the Blast Furnace and Steel Plant last year.

One misses a chapter on refractory materials for the open hearth, which would, if added, make the book more complete. On the other hand, there is an agreeable surprise at the end in the form of a 13-page bibliograph and reference guide, which alone is worth any price charged for the book, so much the more as it seems to be a rather complete survey of any and all articles, which have appeared in the last 10 or 15 years in the various leading steel industry periodicals in all parts of the world. A table at the end of the book, giving the evolution from the iron ore to finished products, has already been criticised in issue 27 (page 1078) of Stahl und Eisen, to which we refer.

There is need for a book of this character, not only in Germany but here also, and the more international the description of the various appliances is the more valuable is the book, undoubtedly. Mr. Hermann's book is typical German, and consequently of little value to the average American reader, except to the student of certain machinery and mechanism. If one would attempt again to write a book of this nature it is essential, not merely desirable, that the writer has more than a perfunctory knowledge of practice outside of Germany if he intends to be taken seriously. Impressions gained from reading of American magazine articles and unsupported by any personal contact with our leading industry, can hardly fail to be misconclusions in many cases, from which a book for students and designers should be free.

BUREAU OF MINES CHANGES

A. W. Ambrose, chief petroleum technologist of the United States Bureau of Mines, has been appointed assistant director of the bureau, to fill the vacancy created by the resignation of A. E. Holbrook, who has accepted the position of dean of the mining school at Pennsylvania State College. The appointment is effective October 1. The duties of F. J. Bailey, assistant to the director, have been increased by assigning to him virtually all of the business matters of the bureau formerly handled by the assistant director.

NEWS OF THE PLANTS

George W. Armstrong, head of the George W. Armstrong Company, Fort Worth, Tex., manufacturer of iron products, and associates have organized the Armstrong Steel Company with a capital of $2,500,000 and 25,000 shares of common stock, no par value. The new company will succeed to the present Armstrong business and plans are being arranged for the remodeling of the plant into a modern steel mill. The production of bar iron and other commercial iron products will eventually be entirely discontinued and the bulk of operations concentrated on steel ingots and a line of steel products used extensively in this district. New mills will be constructed, estimated to cost close to $1,000,000, including machinery and operating equipment. To provide funds for this expansion the company is arranging for the immediate sale of a preferred stock issue aggregating $2,500,000. George W. Armstrong will be chairman of the board of the new company; R. L. Van Zandt will be president, and David R. Knapp, consulting engineer and formerly connected with the Eastern Steel Company, Philadelphia, will be vice president, in charge of operations.

The Wallingford Steel Company, Wallingford, Conn., recently organized with a capital of $200,000, is completing the installation of the initial machinery at its new local plant, and plans to inaugurate production at an early date. The new plant will specialize in the production of cold rolled steel products.

The Nekoosa Iron Works, Nekoosa, Wis., has plans under way for the construction of a new addition to its plant for increased production, comprising a one-story structure about 50x80 feet, and adjoining building 50x75 feet, estimated to cost close to $50,000, with equipment. Work will be commenced at an early date.

The Columbia Steel Corporation, 503 Market Street, San Francisco, Cal., comprising a recent merger of the Columbia Steel Company, San Francisco, and the Utah Coal and Coke Company, Salt Lake City, Utah, operating in Carbon and Iron Counties, Utah, has preliminary plans in progress for the construction of a number of additions to its plant at Pittsburg, Cal. The expansion will include a new rod mill, wire mill, nail works, and other structures, estimated to cost more than $1,500,000, including machinery and installation. It is proposed to commence work early in October and rush the structures through to completion. The new company is capitalized at $15,000,000.

The Greenville Steel and Iron Company, Greenville, Pa., care of the Greenville Chamber of Commerce, recently organized, has acquired a tract of property totaling about 35 acres of land for the construction of a new steel plant, to be devoted primarily to the production of alloy steels. The initial works, as projected, will include a 500-ton blast furnace, four 60-ton open hearth furnaces and one 10-ton open hearth furnace. The latter unit will be used almost entirely for experimental work. Other plan departments will include four rolling mills, cold drawing mill, electric power plant with capacity of about 15,000 horsepower, and other miscellaenous buildings. It is expected to develop an initial annual output of about 180,000 tons of pig iron and close to 165,000 tons of steel. Of the pig iron production it is estimated that the plant will use, itself, about 110,000 tons. Wherever possible the machinery installed will be electrically operated. The new plant is estimated to cost in excess of $1,500,000. The company is capitalized at $2,500,000 and is headed by Colonel H. P. Boke, formerly vice president of the Carnegie Steel Company, Pittsburgh, Pa.; H. E. McConnell, metallurgical engineer, also previously connected with the Carnegie Company; A. H. Davies will be general plant superintendent.

The Bethlehem Steel Corporation, Bethlehem, Pa., has tentative plans in progress for the construction of a number of additions to its plant at Sparrows Point, near Baltimore, Md. The work will include a new open hearth mill, plate mill, sheet and tinplate mills and miscellaneous structures, in full, to provide for an increased capacity of close to 300,000 tons per annum.

The Mesabi Iron Company, 25 Broad street, New York, N. Y., operating iron ore properties in the Mesabi Range, Minn., has arranged for a stock issue of $600,000, a portion of the proceeds to be used for extensions and improvements. The company is devoting a large portion of its output to the manufacture of iron ore concentrate, sinter. The present mill has a capacity averaging from 400 to 500 tons of sinter per day, with course crushing plant, power plant and other mechanical buildings used for operation. D. C. Jackling is president and W. G. Swart, vice president and general manager.

The International Harvester Company, Chicago, Ill., will commence the immediate construction of a new one-story open hearth furnace at its Wisconsin Steel Works, One Hundred and Sixth Street and Torrence Avenue. The plant unit will be 143x504 feet, and is estimated to cost approximately $300,000. The general contract has been awarded to the Bates & Rogers Construction Company, 37 West Van Buren Street, Chicago.

The Otis Steel Company, Cleveland, Ohio, has arranged for an increase in capital from 500,000 to 1,000,000 shares of stock. The excess being used in connection with a new bond issue to provide for plant extensions for considerably increased output. Plans are underway for a new steel plant to consist of open hearth furnaces, rolling mills and subsidiary structures, estimated to cost close to $1,000,000, including machinery. The new works will be used primarily to supply the sheet bar and slab requirements for the general plate and sheet mills of the company. It is expected to call for bids at an early date.

The Coast Range Steel Company, Victoria, B. C., organized a number of months ago with a capital of $15,000,000, is arranging with the provincial government for the construction of a new steel plant. It is proposed to issue bonds for about $4,000,000, to provide for the initial construction, while the ultimate plant will cost close to $10,000,000. It will consist of a blast furnace, open hearth plant and other subsidiary structures, equipped for an annual capacity of about 120,000 tons of steel. H. J. Landahl is one of the heads of the corporation.

WITH THE EQUIPMENT MANUFACTURERS

NEW PORTABLE MEASURING INSTRUMENT MANUFACTURED BY WESTINGHOUSE CO

Portable ammeters and voltmeters of a new type, of which compactness, ruggedness, simplicity of construction and accuracy are important features, have been added to the line of instruments made by the Westinghouse Electric and Manufacturing Company.

The instruments, known as type PX-3 portable instruments, are direct reading meters for general testing purposes. The field of their applicaion is wide, including central station analysis tests; trade school, high school, and college equipment tests, and battery apparatus tests. They are particularly well suited for automobile and battery testing. A set of six of these instruments is not as bulky to carry as one ordinary large portable instrument.

The movements of these instruments, which operate on the D'Arsonval principle, are light in weight, assuring a minimum of pivot and jewel wear and preventing injurious effects from shocks or vibration. Since the complete movement is mounted on a micarta sub-base which can be removed as a unit, it can be completely adjusted outside of the case where all parts are accessible.

The cases are made of moulded composition. This material is not only strong, but acid resisting, which makes the instruments particularly useful for battery testing. Some other distinctive features of the instruments are that they have a degree of accuracy not previously found in instruments of such a small size; the relation of torque to weight is more favorable than in larger instruments; the round open-face construction gives good lighting on the scale; the dials are clear and legible with a mirror under the pointer to eliminate parallax; the calibration is as permanent as that of larger instruments, and all the instruments have external zero adjusters.

NEW SQUIRREL-CAGE INDUCTION MOTOR

The Electric Controller and Manufacturing Company of Cleveland, Ohio, are putting on the market a squirrel-cage induction motor. They make some very broad claims regarding this motor and have introduced new ideas in motor design. It is claimed that this motor is better not only from a mechanical standpoint, but from the standpoint of efficiency, power-factor and torque.

No filing or fitting is allowable in the manufacture of the motor, but it is so carefully built mechanically that the various parts must fit or be rejected. The stator frame is cast around the stator limitations, thus insuring perfect rigidity and alignment. The shrinkage of the frame after pouring puts the laminations under heavy pressure and removes any possibility of the motor becoming nosy. The frame is of the skeleton type, so that the major portion of the stator laminations are exposed to the air. Fan blades are used on only a few of the 900-rpm. motors. The 1,2000 and 1,800-rpm. motors do not have fan blades, as most of the cooling is done by direct contact of the laminations with the air.

The stator windings are all impregnated twice: once after the coils are wound and again after the stator is completely assembled and wired. All coils are form-wound, and open-slot construction is used. The same care is used in the manufacture of all of these stators that is ordinarily used only when severe moisture or oil paper conditions are to be met.

The bearings are extra large and each bearing is provided with two oil rings, one of which is sufficient to properly lubricate the bearing. The extra ring is used as a factor of safety.

The oil wells are larger than is ordinarily used, so as to give further protection against hot bearings. The rotor has cast end rings and the shaft is made much larger than standard engineering practice demands.

COMBINATION CLUTCH AND BRAKE FOR TUMBLING MILLS

The "safety first" movement has resulted in many improvements in foundry and shop equipment. One of the latest is a combination clutch and brake mechanism for tumbling mills.

This is a simple and really fool-proof device, controlled by a hand lever. Shifting this lever towards the mill engages the clutch and starts the mill To stop the mill, the lever is moved in reverse direction, passing through neutral to the braking position.

The advantages of such a mechanism are easily seen. A loaded mill can be brought to rest at exactly the right point for unloading and without loss of time. Holding the mill in place by a wood prop or a bolt thrust into the gearing, as is commonly done, is always dangerous. With the combination clutch and brake it is impossible for the barrel to turn after the brake is set, even though the barrel is unequally loaded.

This mechanism was devised by Whiting Corporation, Harvey, Ill., and wa sthoroughly tested in their own foundry before being placed on the market. U. S. Leters Patent were issued June 6, 1922.

PORTABLE WELDING SET IS SEMIAUTOMATIC

To increase the applicability of its semiautomatic arc welding apparatus and to make it available for use in any part of the factory or shop, the General Electric Company, Schenectady, N. Y., has placed on the market a portable set. This unit comprises a complete equipment, with support for a wire reel, mounted on a small truck that can be pulled over the shop floor or lifted by a crane. The equipment weighs about 400 pounds.

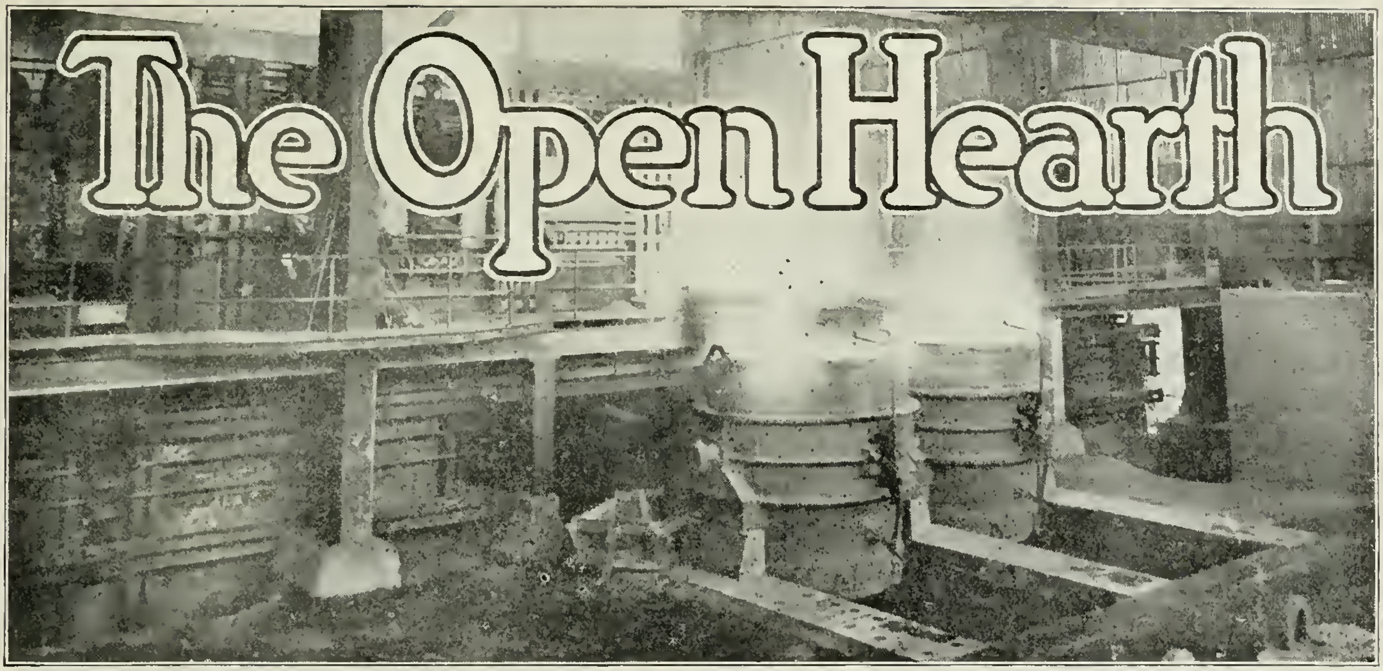
Briefly, the outfit consists of a semiautomatic lead, an automatic welding head with control, and a standard for holding a reel of electrode wide. Power is supplied to the arc through a flexible cable with a plug for attaching it to the nearest welding circuit. The reel carrier is equipped with a brake and designed to take any size up to 2½ feet in diameter.

It is believed that this portable set will be used to advantage in repairing parts of machines in place when these parts are too bulky, inconvenient, or otherwise impractical to move. It is useful also for doing routing welding of all kinds, such as fillin gholes in castings, welding seams in pipes of tanks and similar work.

KEY-TITE SELF-FITTING KEYS

Smith & Serrell, Newark, N. J., have perfected the details of Keytite Self-Fitting Keys which give an easier and better way to obtain a fit between keys and keyways than by the old method of hand fitting.

The Open Hearth



Charles E. Hulick, superintendent of blast furnaces of the Thomas Iron Company, Hokendauqua, Pa., has resigned, effective September 1.

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Joseph Edmunds was recently appointed superintendent of finishing mills, No. 2 plant, Inland Steel Company, Indiana Harbor, Ind. Mr. Edmunds was formerly superintendent of structural mill, Illinois Steel Company, South Chicago, Ill.

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E. L. Ford is president of the Youngstown Steel Company, Youngstown, Ohio, which is installing a mechanical puddling plant at Warren, Ohio. Mr. Ford is a son-in-law of Joseph G. Butler, Jr., Youngstown, and has been associated with the development of the iron and steel industry of the Mahoning Valley for many years. Mr. Ford is a director of the Youngstown Sheet and Tube Company and a member of the executive committee of the Brier Hill Steel Company. The mechanical puddling machine to be used in the Warren installation is the result of years of experimentation by Mr. Ford and associates. It is modeled after a design by Mr. Ford, fully covered by patents. Plans provide for an extensive plant, to consist of two blast furnaces, by-product coke oven complement and 16 mechanical puddling machnes.

√ √

Charles O. Rowe has become associated with Carson & Company, Pennsylvania Building, Philadelphia, and will have charge of the company's steel department.

√ √

Charles C. Hill was general superintendent of the Schoenberger works of the American Steel and Wire Company, Pittsburgh, up until two weeks ago, when he was transferred to the Newberg steel works of this company, Cleveland, as general superintendent, succeeding Bertram D. Quarrie, now general manager of the Otis Steel Company, Cleveland. Mr. Hill has been associated with the American Steel and Wire Company since 1892 in the capacity of timekeeper, chief clerk, superintendent Bessemer department and assistant general superintendent. He was appointed general superintendent of the Schoenberger works last October. Mr. Hill's successor will be appointed soon.

√ √

William J. Fountain resigned his position with the blast furnace department of the Illinois Steel Company at Joliet to become associated with the Cleveland-Cliffs Iron Company, at Marquette, Mich., in the capacity of blast furnace superintendent.

√ √

George T. Christopher has been made general superintendent of the Dayton Engineering Laboratories Company, Dayton, Ohio. He was formerly assistant superintendent and production manager.

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Samuel Hench has been made superintendent for the Sterling Steel Foundry Company, Braddock, Pa., of which, for the past five years, he has been foreman.

√ √

George M. Thompson resigned as vice president of the Wickwire Spencer Steel Corporation and will retire from active business for a time. However, he will continue as a member of the board of directors. Mr. Thompson has been connected with the wire industry for more than 27 years in the Worcester, Mass., district.

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J. J. Becker has been made superintendent of the blast furnace plant of the Temple Furnace Company, Temple, Pa. This company was incorporated recently to take control of the plant formerly operated by the Seaboard Steel and Manganese Company. Repairs have been made and the plant will start operation in the near future.

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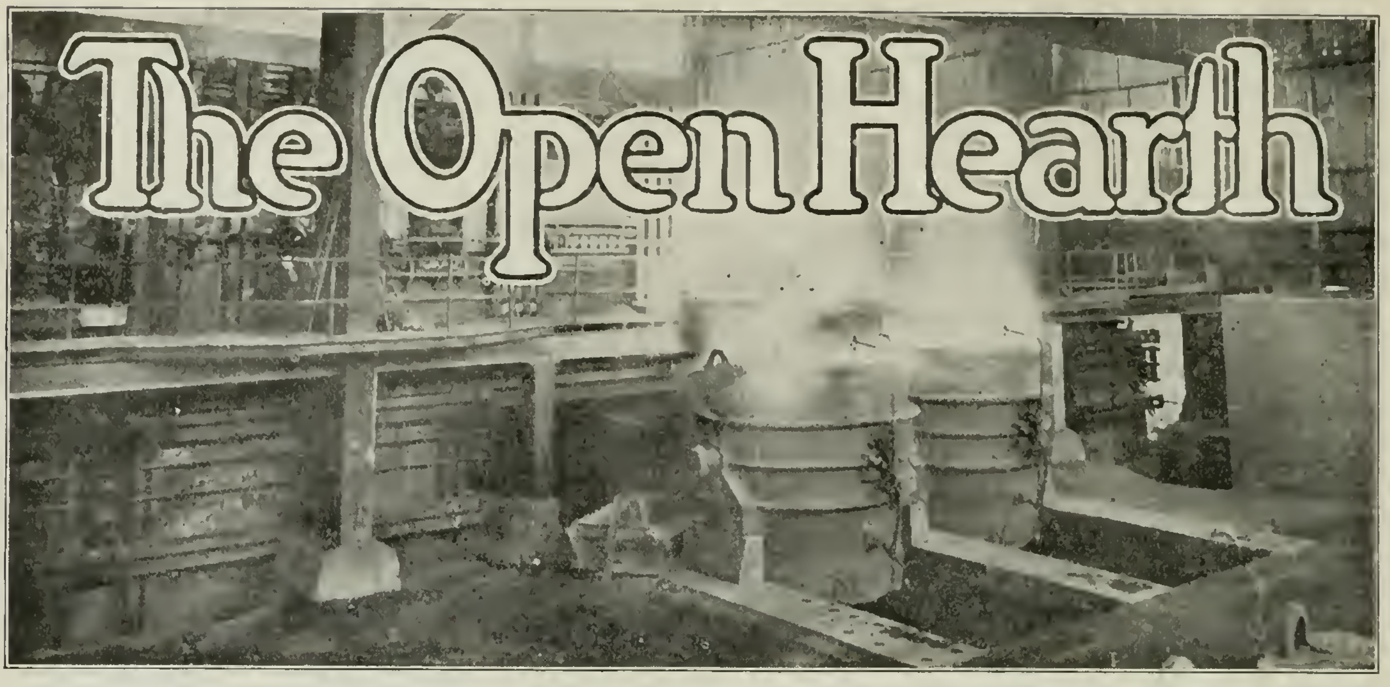
E. W. Rossiter has been appointed engineer of construction for Freyn, Brassert & Company. He was previously chief engineer of the Interstate Iron and Steel Company, Calumet River, Chicago, and prior to that was with the American Sheet and Tin Plate Company, the Minnesota Steel Company and the Canadian Steel Corporation, Ltd., Ojibway, Ont.

√ √

Harold L. Stevens, who has been appointed general sales manager of Central Iron and Steel Company, Harrisburg, Pa., has spent practically his entire life in the steel business. He was employed in the Sweet mills at Syracuse, N. Y., and later by the Sweet's Steel Company, Williamsport, Pa. Some years later he joined the Lackawanna Steel Company, in the Buffalo sales department. He was made New England district sales manager of the Lackawanna Steel Company about 11 years ago, with headquarters in Boston. A native of Portland, Me., he attended Cornell Universty and is an ex-president of the

The Open Hearth



Cornell Club of New England. The change takes effect September 1.

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C. N. Phillips, for the past five years superintendent of the Reading Steel Casting Company, Reading, Pa., has taken charge of the steel foundry department of the Chapman Valve Manufacturing Company, Indian Orchard, Mass. Mr. Phillips was connected with the Reading Steel Casting Company for a period of 22 years, starting as a workman and advancing by stages to the position of superintendent. He was also identified with a valve manufacturing business in Reading.

√ √

Arthur Whitcraft, manager manganese steel sales, Hadfield-Penfield Steel Company, Bucyrus, Ohio, in addition to his previous duties, has also been placed in charge of all foundry operations at the South Works at Bucyrus, Ohio

√ √

J. A. McCrory, formerly secretary and general manager of sales of the American Steel Company, Pittsburgh, and C. T. Baird, who was president of Charles T. Baird & Company have formed a partnership under the firm name Baird & McCrory, Inc., with offices at 140 Nassau street, New York.

√ √

F. D. Gordon was recently appointed manager of the Gary Screw and Bolt Company Works, Gary, Ind., succeeding C. E. Carr, who had been manager for a number of years.

√ √

A. L. Roberts has been appointed sales engineer, railroad department of the United Alloy Steel Corporation, Canton, Ohio. Mr. Roberts was formerly master mechanic of the Lehigh Valley Railroad and recently chief engineer of the Atlas Crucible Steel Company.

√ √

Bertram H. Lawrence, district engineer, American Steel and Wire Company, Worcester, Mass., has been made chief engineer to succeed W. E. Snyder, Pittsburgh, who recently died. Matthew R. Fish, chief draughtsman, South Works, Worcester, succeeds Mr. Lawrence as district engineer. Mr. Lawrence will have charge of power and mechanical equipment, with headquarters at Pittsburgh, and will take up his duties this month. He originally was with the Chicago office of the company and went to Worcester about seven years ago. His education as a mechanical engineer was received at the University of North Carolina.

Joseph H. Swift, master mechanic, South Works, American Steel and Wire Company, Worcester, Mass., has been made chief draughtsman to succeed Matthew R. Fish, who is now district engineer. Joseph Ashworth, shop foreman at the North Works, succeeds Mr. Swift as master mechanic at the South Works.

√ √

S. P. Ker, Jr., Sharon, Pa., has been appointed general manager of sales of the Ashtabula Steel Company, Ashtabula, Ohio. The company is completing an eight-mill sheet plant. Mr. Ker is a son of Severn P. Ker, president of the Sharon Steel Hoop Company.

√ √

Mr. Charles Gray Cooper, for 45 years identified with the C. & G. Cooper Company, engine builders, Mt. Vernon, Ohio, died at his home in Mt. Vernon at 5 A. M., August 4, 1922, after an illness dating from April, 1918. He was born in Mt. Vernon December 11, 1845, and was the son of Elias Cooper, who, with his brother, Charles Cooper, founded the C. & G. Cooper Company, 90 years ago. He was educated in the public schools of Mt. Vernon and at Oberlin College. Mr. Cooper was one of the pioneer engine builders of this country and practically his entire life was spent in the development and building of Cooper steam and gas engines.

√ √

Mr. D. W. Elliot, general superintendent of the Joseph E. Thropp furnaces, died at his residence at Earlston, Pa., July 24, from apoplexy. Mr. Elliot was formerly connected with the Schoenberger furnaces and steel plant, the Central furnaces in Cleveland, the Donora furnaces, the Cambria Steel Company and the Joseph E. Thropp furnaces.

√ √

Thomas H. Wickenden and Charles McKnight, Jr., have recently joined the development and research department of the Inernational Nickel Company, New York, to undertake development work in connection with alloy steels. Mr. Wickenden was for many years associated with the Studebaker Corporation as engineer-in-charge at the South Bend plant and more recently associated with Zeder-Skelton-Breer Engineering Company in a consulting capacity. Mr. McKnight was formerly works manager of the Carbon Steel Company and engaged for many years in the production of alloy steels.

Some Pointers on By-Product Coke Oven Operations

WEIRTON STEEL COMPANY TO BUILD BY-PRODUCT PLANT

The Weirton Steel Company, Weirton, W. Va., has awarded the Koppers Company a contract to build a by-product coke plant and motor fuel recovery plant. Work already has begun on the first battery of the by-product plant which will consist of 37 ovens of the Koppers Company's new design, with a capacity of producing more than 600 net tons of coke per day, entirely from high volatile coal. It is expected that this unit will be completed and in operation late in the summer of 1923. Ultimately the plant will consist of three batteries of ovens.

The design of the ovens to be built at Weirton is the same as that of the 5-oven battery which has been in operation at the plant of the Chicago By-Product Coke Company for the past six months. Each oven will have a capacity of more than 14 net tons of coal per charge. This new type of oven is about 14 in. wide and embraces an entirely different system of heating than the old Koppers design. The ovens are so arranged that at any time they can be heated with either blast furnace or producer gas, thus releasing all the valuable coke oven gas for use in the steel works. The Chicago plant, with ovens like those to be constructed at Weirton, has been operating on an average coking time of 12 hours and has been on as low coking time as 9 hours 50 minutes.

LIGNITE TAR DISTILLATION

Lignite tars are profitably distilled at reduced pressure, in order to save time and fuel, and to reduce the tendency of the tar to crack. In Germany, it was formerly customary to start the distillation with a pressure of 10 cm. (4 in.) of mercury below atmospheric, and to finish the process at a pressure deficiency of 40 cm. (16 in.). When, during the war, the demand for fuel oils and producer tar from lignite increased, attempts were made to work with higher vacua, while at the same time the capacity of the still was enlarged. Of the various processes introduced, only those of the Deutsche Erdol A.G., of Rositz, seem to have survived, the plants being supplied by the Brunn-Konigsfeld engineering works, which specialize in this field. In one of these plants, described by Dr. E. Graefe, in *Brennstoff-Chemie*, of June 1, the pressure reduction is carried to 68 cm. (27 in.), and there are eight boilers or continuous stills, each of 40 cu. m (1,400 cu. ft.) capacity. The stills resemble horizontal Cornish boilers. They are arranged in series and slightly in cascade, so that the liquid flows from one still into the other. The vapors from each boiler pass into a dephlegmator, which is placed inside the preheaters of the respective boiler, so that distillation begins in the dephlegmator, which is coupled to its own condenser; 16 separate fractions of the distillate may be drawn from the stills and condensers. The still temperatures range from 200 deg. C. to 320 deg. C. The final distillation to coking takes place in special cast iron stills. One of the advantages claimed for the process is that good lubricating oils and paraffins are obtained.

INCREASING THE RATE OF CARBONIZATION

According to a paper read before the Institution of Gas Engineers, it would appear that an increase in the rate of carbonization, caused by alteration in the chemical and physical conditions, is accompanied by improvement in the calorific value of the gas, and of the thermal and volume yields per ton of coal. Improvement is found in every direction.

Very considerable increase in the rate of carbonization may be obtained by selection of those coals which give up their gas above a minimum rate. Except in the case of oxidized coals, the calorific value of the gas, and consequently the thermal yields, are higher for an increased rate.

When an increase in the rate of carbonization is caused by an increase in carbonizing temperature, the results are complicated by the fact that the portion of the gas evolved on the outside of the plastic layer is subjected to an increased degradation. This opposes the tendency of the higher rate to give gas of superior calorific value. Up to the end of a certain time, the calorific value of the higher temperature gas is smaller than that of the lower, but, volume for volume, there is a slight balance in favor of the high temperature gas. After a certain period, when the coal at high temperature is nearly carbonized, the calorific value falls off rapidly, while the coal at low temperature is still producing gas of moderate quality.

An increase in volume and thermal yields per ton follows an increase in rate, due to a higher carbonizing temperature, which it is impossible to obtain at lower temperature.

Volume for volume, the calorific value of the higher temperature gas falls off at a slightly greater rate than the lower temperature gas, but a greater volume of gas is evolved from the former, which quickly makes up for the deficiency.

METALLURGICAL COKE

The problem of utilizing the heaps of such low grade coal that in itself has no marketable value has occupied many minds for many years, but a distinct step forward appears now to have been made. The flotation process of dealing with low grade ores is common in the ore fields, for instance, of South Africa and Australia, and it is the application of this process to what ordinarily may be termed rubbish heaps at the coal pits in this country which has demonstrated the possibility of getting the full value out of these heaps. The most important development, perhaps, is that the Powell Duffryn Steam Coal Company has entered into an agreement with Minerals Separation, Ltd., the company owning the patents, for the treatment of their low grade material, both for briquetting and for the manufacture of metallurgical coke. By the grinding of this material to practically a powder, and its treatment in a simple washing process with a chemical reagent, it has been found possible easily to remove all the superfluous matter, leaving a residue of practically pure coal, and, of course, moisture. Subsequent processes enable this moisture to be reduced to 3 or 4 per cent, and we have a product consisting, to all intents and purposes, of pure coal. When converted into metallurgical coke it has been proved to be a much superior material to the ordinary metallurgical coke, and the company owning the patents is making considerable progress in all parts of the world. This opens up enormous prospects for colliery owners, and it may be that we have at last reached the stage at which the disposal of the large heaps of extremely low grade coal, of which so much has been heard from time to time, will be possible, with advantage to the colliery owners and also to the users of the resultant product.—*Mechanical World.*

TRADE PUBLICATIONS

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has just completed the preparation of a 64-page illustrated publication on mining apparatus. In addition to line material, the publication, which is known as Catalogue 6-M, contains much information about mine safety switches, Frankel solderless connectors, tapes, babbits, solders, micarta gears, mine locomotives and mine locomotive headlights.

Pennsylvania Pump & Compressor Company, Easton, Pa., has issued a new 16-page bulletin, No. 202, describing the company's line of double suction single stage centrifugal pumps and containing useful engineering data.

G. P. Wincott, Ltd, Sheffield, England, have issued a most complete catalogue descriptive of the Wincott furnaces. This company are designers and builders of every type of metallurgical furnace, and have constructed furnace equipment for the leading steel plants in Great Britain and the Continent.

Charles J. Clark Blast Meter Company, Gladbrook, Iowa, have issued a booklet describing the engineering and operating details of the Clark blast volume meter, velocity meter and mercury blast pressure gauge. This meter is used to measure volume rather than pressure.

The F. J. Ryan & Company, Philadelphia, have issued several bulletins on electric furnace subjects, under the tiles of "Electric Heat and What It Is" and "The Electric Resistor." Either will be sent upon request.

The Ohio Electric and Controller Company have issued a pamphlet descriptive of the ball bearing motor which they have introduced to the trade. This new line of small motors has been designed to meet the demand for high grade motors for application to domestic appliances, pumps, machines and other devices whch are operated from lighting circuits.

"A Neglected Source of Economy" is the title of a new publication issued by the Armstrong Cork and Insulator Company, Pittsburgh, Pa. It deals with the savings that can be effected in manufacturing plants by the use of refrigerated drinking water systems.

Unique and attractive best describes the new folder just issued by the Van Dorn & Dutton Company, gear manufacturers, Cleveland, Ohio. It is entitled "Bringing the Van Dorn Plant Home to You." It is a complete description of the Van Dorn plant.

Bulletin A, giving a condensed description of the Quigley powdered coal system and appliances has just been issued by the Quigley Fuel Systems, Inc., New York City. The layout of a typical coal milling plant is shown and the methods of fuel distribution and control briefly described

W. A. Jones Foundry & Machine Company, Chicago, Ill., announce the new catalogue No. 24, on Jones gears. This catalogue lists a most complete line of cast-tooth gear patterns. In additon it contains list prices for Rawhide pinions as well as miscellaneous information useful when laying out gear drives or for estimating purposes.

TRADE NOTES

F. J. Ryan & Company, industrial heating equipment manufacturers, Wesley Building, Philadelphia, announce the closing of contracts for equipments to be installed for the following concerns: Bethlehem Steel Corporation, American Fork & Hoe Company, J. G. Brill Company, American Steel & Wire Company, Webb Wire Works.

Monroe L. Patzig, 206 Eleventh Street, Des Moines, Iowa, has been appointed representative of the Conveyors Corporation of America, 326 West Madison Street, Chicago, for the sale of their American trolley carrier. Mr. Patzig's territory lies in Central Iowa.

Scheid Engineering Corporation, 90 West Street, New York City, has been appointed metropolitan and export representative for the Franklin Moore Company, Winsted, Conn., manufacturers of material handling machinery for industrial plants.

The Cambria Steel Company have placed with Arthur G. McKee & Company, Cleveland, a contract for the design and furnishing of materials for their No. 4 furnace top at Johnstown, Pa. The new layout will include a McKee revolving distributor and auxiliary furnace top equipment.

The Syracuse Lighting Company, Syracuse, N. Y., proposes to install three 5000-kva. transformers at its Solvay Station and one 5000-kw. frequency changer at its Fulton Street Station. The contract for both these installations has been awarded the U. G. I. Contracting Company.

The Conveyors Corporation of America, 326 West Madison Street, Chicago, has appointed the Mid-West Engineering Sales Company, Masonic Temple, Cedar Rapids, Iowa, representatives in Eastern Iowa for the sale of American trolley carriers, which is coal handling equipment of the monorail type.

Des Moines, Ind., Gas Company will shortly erect a 2,500,000 cu. ft. capacity storage holder. The contract for installing the foundations and supervising the erection of the holder has been awarded to the U. G. I. Contracting Company of Philadelphia.

Arthur G. McKee & Company, Cleveland, have been awarded a contract by the Rochester & Pittsburgh Coal & Iron Company for designing and installing a new trestle and storage bins at the plant of the Adrian Furnace Company, DuBois, Pa. The improvements to be made include a steel and reinforced concrete trestle structure approximately 480 ft. long, six ore bins, coke bin and coke breeze handling equipment. The coke bin will be centrally located, discharging direct over cascade type screens into the skip cars, and will provide storage for approximately 135 tons of coke. Two 80-cu. ft. capacity scale cars will be furnished for handling materials from the ore and limestone bins.

A new electro-graphitic brush, known as "259," has been placed on the market by the National Carbon Company, Inc. Exhaustive tests on a large variety of d.c. motors and generators, and on the d.c. side of rotary converters, have demonstrated that it is adapted to a very wide range of voltages, current densities and speeds on undercut commutators

Changes affecting the personnel of the Atlanta, Denver, Seattle, New York, San Francisco and New Orleans offices have been announced by officials of the Westinghouse Electric & Manufacturing Company. In the Atlanta office, R. H. Moore has been appointed office manager and Thomas Fuller has been made manager of the Central Station division and has been placed in charge of the sale of supply apparatus. E. C. Means has been appointed manager of the Central Station and Transportation divisions of the Denver office and J. P. Sprunt, Jr., has been made manager of the Merchandising division, which was recently organized there. Mr. Sprunt will also have general charge of the sale of supply apparatus in the Denver territory. J. G. Miles has been appointed manager of the Central Station division and has been placed in general charge of the sale of supply apparatus in the Seattle district. A. W. Eshelby has been appointed manager of the Transportation division and A. A. Miller has been made special representative in large negotiations and power developments in the Seattle office. C. V. Holmes has been appointed district auditor with headquarters in the New York sales office. Edward C. McCarty has been appointed treasury and accounting representative of the San Francisco office, succeeding A. L. Austin, resigned. O. P. McCord has been appointed branch manager of the New Orleans office.

Contracts for the construction of furnaces for the new seamless tube plant of the Weldless Tube Co., Wooster, O., have been placed with Buell, Scheib & Mueller, Inc., Columbia Bank building, Pittsburgh.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., OCTOBER, 1922 No. 10

Bases of Modern Blast Furnace Practice

Outline of Bases Upon Which Modern Blast Furnace Practice Has Been Built Up—Shows How Adoption of These Methods Lead to a Desirable Improvement Both Regarding Economy and Output.

By A. K. REESE

BEFORE discussing these prime factors in detail, it might be as well to consider the objects which modern blast furnace practice seeks to obtain. That practice is distinctly the result of evolutionary progress, the modern phase dating from 1894, when James Gayley introduced the low bosh at Braddock, Pa.—up to the present, the era of the large hearth diameter and steep bosh angle.

There are three principal objects in all blast furnace practice ranking in importance in the following order—quality, economy and quantity. The first is essential The second is commercially of great importance. The third is highly desirable, particularly in its bearing upon the second. No. 1 may be obtained independently of the other two. No. 2 may be obtained, to a degree, independently of No. 3. No. 3 is, to a degree, subject to Nos. 1 and 2. In all blast furnaces one of these objects has been the limiting factor in the attainment of the others.

The object sought through the application of so-called modern practice may be described thus:

> Consistent with quality to produce the greatest possible economical quantity, and as any material increase in quantity has a direct and favorable bearing upon economy this description of the object of modern blast furnace practice may be condensed to—*the attainment of the greatest possible quantity consistent with quality.*

The degree to which this object has been attained in certain localities, in comparatively recent years, resulting in normal economical outputs of from 400 tons to 600 tons per 24 hours, is well known, and demonstrates the great commercial advantage to be obtained by the adoption of the principles and methods by which it has been attained, in those other localities which up to the present have not yet fully adopted them.

There may be, and doubtless are, some makers who are still of opinion that with their particular materials the principles and methods of so-called modern blast furnace practice are not applicable. It is with the hope of convincing them, and of strengthening the growing belief of others, that the author has undertaken this paper, for it is his firm conviction that those principles and methods are adaptable to any iron bearing materials which are workable in a blast furnace, subject of course, to suitable fuel and flux being obtainable within even a wide degree of quality, and subject, likewise, to a minimum degree of variation in that quality for any individual operation. He feels convinced that their adoption will lead to so great an advantage as to constitute almost a revolution in the pig iron industry in those localities where they have not hitherto been applied.

The four prime factors above referred to are:

1. Preparation of Materials.
2. Furnace Design.
3. Auxiliary Equipment.
4. Method of Operation.

Preparation of Materials.

That the mechanical and physical conditions of the materials charged into a blast furnace have a most important bearing upon its successful and satisfactory operation, affecting both its operative conditions and the economy of the results obtained therefrom, is a fact which no blast furnace operator is likely to dispute, but while it is true of any blast furnace it is particularly true in its bearing upon the operation of the modern blast furnace. One of the essential conditions of satisfactory operation is that there shall be as nearly as possible uniformity of chemical reactions, and of physical movement of the materials throughout the whole cross-section in every zone of the furnace. Two elements are required to obtain this in theoretic perfection, namely, perfect uniformity in the size and density of the materials charged, and a sufficient blast volume to produce the condition of a plenum throughout the whole furnace interior. While it is, of course, impracticable to obtain for blast furnace use materials of perfectly uniform size and density in each of the three classes of materials used in pig iron smelting—fuel, flux and ore—it is practicable to approximate to a degree to that condition by the use of proper means for their preparation.

It is obvious that the feature which most directly bears upon the essential condition above mentioned is that of distribution, and in order to obtain as nearly as practicable uniformity of distribution such preparation

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Paper presented at British Iron and Steel Institute Autumn meeting, September, 1922.

as will give as nearly as practicable uniformity of size must be resorted to. For reasons which will be referred to later, uniformity of size only is not, however, sufficient; for example, uniformly large size, while giving uniformity of distribution, would be detrimental to economical operation. The preparation of materials must be in the direction of uniformly small size.

Fuel (*Coke*).—While this principle is much more important in its application to the ore and flux than to the fuel, it also applies, to a degree, to the latter. As rapidity of action is largely dependent upon rapidity of combustion of the fuel, it is desirable that the fuel should not be charged in lumps of excessive size, and preferably should not exceed 4 inches to 6 inches. This is, of course, assuming that the coke is of proper physical condition. It may be said here that the physical quality and chemical purity of coke for blast furnace use are of the greatest importance. It should be strong, but of not great density, and as low as possible in ash and sulphur. There is nothing which more greatly interferes with the regular and economical operation of a blast furnace than soft, friable, or high ash coke, as everyone connected with the industry has experienced during late years under the conditions existing during, and for some time after, the late war. The disadvantage of high sulphur in the coke need not be emphasized.

The coke as charged into the furnace should be thoroughly screened to free it from smalls, commonly known as breeze, and should be of sufficient strength to prevent the excessive formation of smalls in the furnace through the crushing effect of the burden. The strength should not, however, be of the kind which is produced by great density which destroys the cellular structure. A dense coke burns slowly and is, therefore, inimical to rapid combustion, which is necessary for fast driving, whereas cellular structure permits the heat and the agents of combustion to penetrate readily to the interior of the lumps, thus facilitating combustion. On the other hand, a very open cellular structure produced at the expense of strength is equally to be avoided as tending to produce smalls through its lack of resistance to crushing by the weight it has to bear, and abrasion by its movement in the furnace. Such a fuel is also subject to excessive waste in the upper regions of the furnace before it reaches the zone of its usefulness, owing to the greatly increased reaction upon it of the CO_2 in the gases—$CO_2 + C = 2CO$. It is, therefore, of the greatest importance in modern blast furnace practice that coke makers should give the greatest possible attention to the production of a coke combining these two essential features—strength and porosity. There are a number of factors entering into this problem of blast furnace coke making, by the careful study of which the makers may arrive at the production of coke having the desired physical properties described above. Some of these are the coal mixture, the mechanical condition of the coal as charged and its compactness in the oven, the oven temperature, the rate of carbonization, and uniformity of coking action throughout the coking chamber. It would seem hardly necessary to mention the great importance of chemical purity in the coke, as naturally the higher its carbon content the greater its efficiency. It is surprising, however, how much coke is produced with high ash and sulphur content for blast furnace use; in many cases, undoubtedly, the result of insufficient or inefficient washing of the coal, or insufficient attention to the selection of the coal for the production of blast furnace coke. Care in selection and efficient washing of coal for coke production are, therefore, of very great importance in their bearing upon economical blast furnace operations, and every possible effort should be made by blast furnace owners to induce coke makers to meet their requirements as to mechanical, physical and chemical quality. It is the carbon which does the work in the furnace, and every decrease in the percentage of ash increases the available carbon and tends in other ways towards a higher degree of efficiency. In addition to the higher fuel value of low ash coke, it is lighter in weight, requires less limestone for fluxing the ash, and a lower amount of the fuel charged is required for forming and melting the slag produced from the coke ash. It is estimated that the formation and melting of blast furnace slag requires approximately 25 per cent of its weight in fuel, therefore, for every cwt. of slag produced from coke ash ¼ cwt. of fuel is lost so far as the smelting of iron ore—the primary object of the blast furnace process—is concerned.

Iron Ore.—From the standpoint of preparation, the iron ore is the most important of all the materials charged into the blast furnace, owing to the extremes in mechanical condition, from fines to large lumps, in which most iron ores are received from the mines, and the great variety of physical characteristics in different ores. The operation of the blast furnace is much more usually affected, for good or ill, by the mechanical condition of the iron ore than that of either fuel or flux. It is, therefore, of prime importance that this condition should receive very careful attention and whatever steps are necessary should be taken, in the way of preparation, to convert it to that condition—or as near to it as is practicable—as will insure the most beneficial effect upon furnace operation.

There are two principal features directly affected by the condition of the iron ore, both bearing upon the rate of production and upon economy. These are reducibility and distribution. The degree of reducibility of an iron ore depends primarily upon its density, a characteristic which in itself is not readily altered, except with dense ores containing high percentages of protoxide of iron (magnetite), the reducibility of which may be increased by subjecting them to a roasting process in an oxidizing atmosphere, thus converting the protoxide to peroxide of iron.

Rough Ores.—The rate of reduction in the furnace may, however, be materially increased for any particular ore containing lumps, whatever its degree of density, by increasing the surface area exposed to the action of the reducing agents. The obvious method of attaining this increase in surface area is by breaking the lumps into a number of smaller pieces. The extent to which this operation may be carried is, of course, limited by the cost of breaking the ore (a commercial consideration), and the tendency of any particular ore to produce an excessive proportion of fines in the breaking. The latter tendency, however, really does not exist to any considerable extent in ores whose condition allows of their being broken at all, for whatever smalls may be produced in the breaking are usually of sufficient size not to be classed as fines and may, therefore, be safely charged into the furnace with the larger products of the breaking operation.

The increase in the rate of reduction obtained by thus increasing the surface area exposed to the agents of reduction in the furnace has, in addition to the higher possible rate of production, a very important effect upon economy of production. There are two principal reducing agents in the blast furnace process, carbonic oxide and solid carbon, and it is generally accepted that reduction of iron oxide by carbonic oxide, in the upper zones, is a much more economical reaction than the reduction of iron oxide by solid carbon in the lower zones. It is, therefore, highly desirable that the whole or the greatest possible portion of the iron oxide should be reduced by carbonic oxide gas, and that this reduction should be completed before any lumps of iron oxide have reached the zone where conditions permit, in excess, the uneconomical reaction between them and solid carbon. It is obvious that the surest way of attaining this is to so increase the possible rate of reduction of the ore by increasing its surface area, as described above, that the maximum reduction may be effected by the carbonic oxide gas in the upper zones of the furnace. If this precaution of increasing the surface area by breaking the lumps of ore before charging into the furnace is neglected, the larger unbroken lumps will escape thorough reduction by carbonic oxide gas with consequent waste of fuel, particularly if any attempt be made to increase materially the rate of production by rapid driving. To obtain a high rate of production, with economy and quality, it is therefore necessary to prepare the ores in the manner described.

The degree to which it is commercially practicable to crush an ore depends upon its density. Experience has indicated that all ores should be crushed to sizes not exceeding such as will pass through a 3-in. or 4-in. ring, although ores of great density may be advantageously crushed to even smaller sizes. The standard of 3 or 4 in., which seems rather small for ores of a high degree of reducibility—the so-called "soft" ores—is not determined wholly from the standpoint of degree of reducibility, but also by its bearing upon distribution.

The question of the distribution of ore in a blast furnace is of the highest importance in its bearing upon regularity of operation, this in turn affecting most vitally the economy, quality and output.

This question has been referred to above in a general way in connection with uniformity of action in the furnace, but important as that is as regards all the materials, solid and gaseous, entering into the blast furnace operation, the distribution of the ore is the most important consideration in regard to the solid materials.

In the consideration of this question it is necessary to keep in mind the great essential—*equality of action throughout the whole of every cross section of the furnace interior.* Except for the fact that the operations are taking place in a vertical shaft of circular cross section, this result would be obtained, theoretically, only with materials of exact uniformity in size and density, but the fact just mentioned introduces a feature which interferes with this theoretical requirement. It is a well known fact that the gases have a natural tendency to ascend next to the walls and would do so to the neglect of the interior if the furnace were filled with materials of exact uniformity in size and density. It is necessary, therefore, in order to secure approximate equality of action, to have a somewhat greater resistance to the passage of the gases in the materials nearest the walls than in the interior. It is to this condition that the ordinary bell and hopper charging apparatus owes its satisfactory use, discharging the materials as it does in such a way that a greater proportion of the smaller particles remains next to the walls, thus providing the somewhat greater resistance to the ascending gases required there. In order that this distribution by bell and hopper charging may give the desired result the relation of the diameter of the bell to the diameter of the furnace throat at the stock line is of material importance, as likewise that the falling materials shall first strike the materials in the furnace, when nearly full, at about 18 in. from the walls. The former relation is usually a bell diameter 4 to 5 ft. less than the throat diameter at the stock line. The bell angle is usually 40 deg. to 45 deg., and in some cases 50 deg.

This method of charging results in the surface of the material in the furnace assuming the shape of an inverted cone with its base about 18 in. from the walls, from which point they slope away slightly to the surface of the walls. The smallest particles lie on the base of the cone, and between it and the walls, together with a portion of the smaller lumps and rubble. The inner slope from the base to the apex of the cone consists of pieces of gradually increasing size with practically only the largest lumps at and near the apex. This description does not, of course, apply to an ore mixture consisting of all fines, or of lumps of uniform size, conditions which very seldom exist in blast furnace practice, but it does apply to the usual run of ores which consist of a mixture of fines, rubble, and lumps.

It is obvious that the greater the difference between the largest and the smallest pieces, or, in other words, the larger the lumps the greater the sorting action above described, and conversely, the smaller the maximum size of the lumps the less the degree of segregation It is, therefore, further obvious that to avoid excessive segregation, the preparation of the ore by crushing the lumps to smaller, say rubble, size is necessary. The crushing of the lumps prevents excessive segregation in two ways, first, being smaller, they have less tendency to roll down the sides of the inverted cone to the apex and, secondly, the broken pieces have usually sharp and jagged edges, and have, therefore, a greater tendency to lodge nearer where they fall, and the movement of the materials to the center is more likely to be *en masse,* carrying a certain amount of smalls with it. It is thus that preparation by crushing materially improves distribution by preventing excessive segregation, which is a condition directly inimical to the application of modern blast furnace practice.

In the distribution existing when the usual run of ores and limestone are charged "as received," there is, as described above, a core, or column in the center of the furnace consisting almost entirely of the largest lumps, the area of the cross section of this core varying between the size and proportion of lumps to rubble and fines. Between this core and the walls there is an annual ring consisting of a mixture of rubble and smalls, in which the proportion of rubble to smalls gradually decreases until, next to the walls, there are practically only smalls and fines. As previously pointed out, an essential to regular and economical descent of the materials is perfect uniformity of action of the ascending gases upon the whole of every cross section of the material in the furnace, and while this is an ideal condition which may be impossible of full attainment in actual practice, the nearest possible approach to it is of the greatest importance. There can be very little approach to such a condition if the ascending gases are forced, under pressure, through a mass of materials distributed as just described. Very little, if any, of the gases will find contact with the closely packed fine materials close to the walls, and the greater proportion will pass up through the more open structure in the center, the core of large lumps, and a proportion only through the annual ring of rubble and smalls. The result of this unequal distribution of the ascending gases is the faster descent of the largest lumps in the center, and a gradually slower descent of the outlying materials. Such a descending movement of the materials of the various sizes is exactly contrary to what is most desirable. Those which descend most rapidly, owing to their slower rate of reducibility should descend most slowly, and those which descend most slowly, owing to their high rate of reducibility should descend most rapidly. Maximum economy and output are impossible under such conditions, for, apart from the question of irregularity of movement which almost always results from them (see below), it is necessary to provide an excess of fuel to insure the complete reduction of the more rapidly descending lumps before they enter the melting zone (see above, under Reducibility), and the rate of driving is limited by their slower rate of reducibility. Any attempt at really fast driving under these conditions so reduces the ratio of ore to fuel which can be carried that not only is the output not increased, but the fuel consumption is very greatly increased, with the added danger of the production of low grade iron through unreduced ore entering the furnace hearth from over driving, or irregular descent of the materials.

Under the conditions existing in a furnace charged in the manner under consideration, there is always a strong tendency towards irregularity of movement, or none at all, in the material nearest the walls, with a gradual building up on the walls. This building up continues until portions either become permanently stationary, forming scaffolds, or masses break away and are precipitated towards the center and into the actively descending materials and rapidly ascending gases, constituting the well known slip. This procedure is more or less frequent and more or less severe, from the small slip, causing temporary production of off grade iron, to the heavy slip or explosion, which either blows off the furnace top, or fills the tuyeres with slag, chills the hearth, "gobbs up" the furnace and puts it out of commission for days, an evil too well known among those who may be interested in this paper to require any emphasis; but to whatever degree it occurs it very seriously interferes with the regularity which is essential to the best results. The disadvantages from the accumulated effects of these conditions are only avoided, and even then not always satisfactorily, by periodical partial clearance of the furnace walls by the use, temporarily, of considerably reduced burdens, or, which is the same thing, by charging extra fuel, at the expense of both economy and output. These evils can only be avoided by the proper preparation of lump ores by crushing.

Fines Ores.—The disturbing effects upon blast furnace operations of the use of any considerable proportion of very fine ores—exaggerating the conditions described under Distribution—are too well known to require special emphasis. Although in modern practice furnace design and method of operation have considerably reduced these effects, such ores are still sufficiently objectionable in this respect to make advisable some treatment to change their character as fines. In this case the process of preparation is the reverse of that for lumpy ores, that is, instead of reducing, it is desirable to increase their size, in order to remove their clogging effect in the furnace, and to prevent their being carried out in excessive quantities, by the escaping gases, into the gas flues.

Various processes have been introduced for this purpose, such as briquetting, nodulizing, and sintering, each of which yields a satisfactory product for use in the blast furnace. Sintering is the more recent process, and has grown very rapidly in favor, owing to its lower production costs, and the large range of materials which may be treated by it, including blast furnace flue dust, the recovery of which alone in some cases warrants the installation of the process, particularly as, in addition to the iron ore recovered, the dust usually carries such an excess of fuel over what is required for its own treatment that a considerable proportion of other fine ore, without fuel, may be mixed and sintered with it. By these processes, and particularly sintering, many ores which, in their natural state, are unsuitable for use in the blast furnace, either owing to their mechanical condition, or high sulphur content, or both, may be rendered suitable.

The Flux (*Limestone or Dolomite*).—Of the solid materials, the flux, being easily acted upon by the heat and chemical reactions, and usually forming a small proportion of the mixture, is of less importance in connection with the question of preparation of materials. It is of sufficient importance, however, to receive consideration, as its mechanical condition has a definite bearing both upon distribution and rapidity of action in their bearing on economy. Although the effect is less in degree, it is the same in principle as in the case of the ore, and for similar reasons the flux should be broken to as nearly as practicable uniform size. In practice it has been found sufficient to break it to sizes not exceeding 4 in. or 6 in., or such as would pass through a 4-in. or 6-in. ring, although there is no disadvantage in breaking it to even smaller sizes. The author has had personal experience with large blast furnaces using oyster shells alone as flux over a considerable period with perfectly satisfactory results, except that there was added to the waste gases a further objectionable feature to their usual asphyxiating qualities, their bad odor.

Blast.—The only remaining "raw material" essentially used in blast furnace operation is the air which supplies the oxygen necessary for the combustion of the fuel.

There is little to be said with regard to the blast under the heading of Preparation of Materials, that is, in its bearing upon modern blast furnace practice as distinguished from practice which is not "modern," except that the usual custom in the latter is to take the air as we find it, although not always in all its purity. Too little attention is usually paid to this point. Natural air in its purest state has its detrimental constituents, but as a rule little attempt is made to draw the supply for the blowing engines even as pure as it occurs. The proximity of boilers and free exhaust auxiliary machinery, and various sources of evaporation, too often charge the air near blast engine houses with quantities of moisture much in excess of that in natural air "in its purest state." In modern practice practically all exhaust steam is condensed, and a large proportion of the auxiliary machinery is electrically driven. There is, therefore, little, if any, opportunity for extraneous moisture to enter the blast engines with natural air. This is a feature of considerable importance, and has an appreciable bearing upon the economy of modern practice.

Although in view of its lack of more general adoption it has no direct bearing upon the subject of this paper there is a treatment to which natural air may be subjected for its improvement for blast furnace purposes, which comes logically under the heading of Preparation of Materials. As a strong advocate of this treatment the author hopes that a discussion of it at this point will not be considered out of place. This is the question of dry blast, or, to be more exact, the treatment of natural air for reducing its hygroscopic moisture to a uniform and low content—a treatment first introduced and practically demonstrated by James Gayley in 1904.

There has been a great deal of discussion, and even contention (mainly theoretical) as to the merits of this process. At the time of its introduction a great stir was caused in iron-producing centers, and during the following years a considerable number of plants were installed for its use in the United States more particularly, and in Europe. Some of these installations are still used continuously, and some are used intermittently in the United States, that is, they are used in the summer months when the moisture content of the air is high, and discontinued in the winter months when the moisture is naturally low. In other cases their use has been entirely discontinued

There is, however, practically unanimous agreement amongst those who have used "dry blast" that its use does improve blast furnace results, although opinions differ as to the degree of the economy. The author has had an opportunity during the past 18 months of discussing this matter with representative American blast furnace operators, particularly as to the reasons why the process has not been more generally adopted and its use continued more generally where plants have been installed. The explanation given is that the benefits obtainable from "dry blast" have been superseded by the great advance in blast furnace results brought about in recent years by improvements in furnace design, and the altered practice following those improvements. In other words, it has been possible to obtain, in other ways, advantages equal to those derivable from "dry blast" under the older practice. It may be a very bold thing for the author to say in the face of these opinions, but he believes that attitude to be a mistaken one, and that if every advantage which can be derived from "dry blast" is provided for, further improved results are obtainable in addition to those already obtained by the means above referred to.

The author has had considerable experience with "dry blast," having used it continuously on two large furnaces during the past 13 years with such satisfactory results that he would have considered its abandonment a very serious step in the wrong direction. It is not his intention to enter here into a discussion upon the advantages of "dry blast" in detail or in general, but there is one very important feature in connection with its use which seems to have been missed by those who have used and abandoned it, either partially or wholly, a feature which, in all probability, explains the attitude adopted towards it in the United States in conjunction with later American practice, and possibly elsewhere. This is the important factor of blast temperature. It is the author's experience, and he believes it is also general experience (although there may be isolated cases to the contrary), that with natural air there is an upper limit to the temperature of the blast which can be used with satisfactory and smooth working for any particular furnace. Any considerable increase beyond this limit causes "stickiness," "hanging," and irregular movement of the materials in the furnace. In his discussions with American blast furnacemen he was told that this was the case even with furnaces of the latest design, and a particular case was cited at one of the most modern plants in America, where very high temperatures of blast were tried with results as above mentioned. The blast temperatures genrally used range from 1150 deg. F. to 1250 deg. F., while with clean gas and modern stove design (and sufficient stove capacity), temperatures as high as 1500 deg. F. to 1600 deg. F. are obtainable.

The economical advantage which could be derived were it possible to make satisfactory use of this additional heat in the blast, need hardly be emphasized, and any practicable means which would render this possible would confer a very important boon upon the iron producing industry. The author's experience is that such a means is available in "dry blast," and that it is this further advantage of dry blast added to those which are already conceded it, which would, if taken advantage of, settle the doubts of those who are still undecided, and convert those who have already condemned it. It may be said that he was in a fortunate position to have available such high temperatures (he has used temperatures as high as 1600 deg. F., normally from 1450 deg. to 1550 deg. F., temperatures under 1400 deg. F. being considered too low); but what was available to him is obtainable by others, and he would emphasize the fact that without dry blast, although available, he could not have used them.

(To be continued.)

ELECTROCHEMISTS STUDY ELECTRIC HEAT

Electric heating, a matter of particular importance at the present time, was one of the leading subjects discussed at the forty-second annual convention of the American Electrochemical society, held at the Windsor Hotel, Montreal, September 21-23. More than 200 delegates and members of other scientific societies attended. President C. G. Schulderberg of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., served as chairman. Addresses of welcome were delivered by Alderman Seybold representing the city, and Dr. R. F. Ruttan of McGill University, on behalf of the scientist of Montreal.

DR. STANSFIELD TO ADDRESS ELECTRICAL ENGINEERS

Prof. Alfred Stansfield, D. Sc. Associate of the Royal School of Mines; Fellow of the Royal Society of Canada, Birks Professor of Metallurgy in McGill University, Montreal, will speak on "Electric Smelting of Iron Ores" before the Cleveland District section of the Association of Iron and Steel Electrical Engineers Monday, October 9, 1922, at the Hotel Winton, 6:30 P. M.

In 1907 Prof. Stansfield, published his first book "The Electric Furnace," but on account of the very rapid development of the art, it has been necessary to make revision whereby the second edition has been placed at the disposal of the engineering profession.

Anyone who has read Prof. Stansfield's books cannot help but be impressed with the thoroughness of treatment of the various subjects relative to electric smelting. It is felt that, since the Professor is coming to Cleveland now with the last word on the subject of Electric Smelting of Iron Ores, which he will illustrate with lantern slides, that the Electrical and Metallurgical Profession of Cleveland has been highly honored. This is an open meeting and everyone is invited.

BRICKS FROM DOLOMITE

At the Columbus, Ohio, ceramic experiment station, the Bureau of Mines has made standard sized bricks from calcined dolomite and from raw dolomite, using 10 per cent of the flux Fe_2O_3, Al_2O_3, SiO_2. Calcined dolomite was found undesirable for making into bricks, as the mud slakes so rapidly, and all samples cracked badly on account of enormous shrinkage during drying and burning. Raw dolomite, together with 10 per cent flux, gives excellent promise.

Corrosion Control by Deactivation of Water

Relative Rate of Corrosion—Protective Coatings—Dissolved Oxygen in Water—Oxygen Removal by Chemical Means.

By FRANK N. SPELLER, B.A.Sc., Member A. S. M. E.

PART 1

REPLACEMENTS made necessary due to corrosion of iron and steel in this country have been estimated to run over 1,000,000 tons per annum. While this is perhaps little better than a guess, it is probably not overstating the facts. Much of this loss occurs in piping, boilers and other closed systems. For example, a large modern building contains over 200 miles of piping of all kinds. There are the arteries of the structure, which are both difficult and expensive to replace. The hot-water piping is most subject to attack, frequently lasting less than 10 years under modern conditions.

One of the most fruitful means for effecting economy is through the elimination of waste. The subject of this paper deals particularly with the conservation of iron and steel in contact with water in closed systems, but it may be well to first outline briefly some of the important facts and principles relating to corrosion in general.

The Electrolytic Theory of Corrosion has been stated in various terms in a number of articles which may be referred to by those who are particularly interested in this phase of the subject.[†] The essential reactions are: The action of hydrogen ions in water which results in the solution of iron; the concentration of hydrogen ions, acidity of solution; the polarization of the metalic surface by deposition of hydrogen which protects the metal from further attack; the retarding effect of ferrous hydrate in solution; and the removal of deposited hydrogen and ferrous hydrate by oxygen in solution in water. Without the last reaction, corrosion cannot proceed to any appreciable extent, except in rare cases where a high hydrogen ion concentration is maintained, as where water contains magnesium chloride. In this case the water when heated brings about the following reaction: $MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl$. In contact with iron, ferrous chloride is then formed, which is hydrolyzed by water ($FeCl_2 + 2H_2O = Fe(OH)_2 + 2HCl$). These reactions are cyclic and will continue in the presence of free oxygen, which disturbs the equilibrium of the last reaction by formation of insoluble ferric hydrate ($4Fe(OH)_2 + O_2 + 2H_2O = 4Fe(OH)_3$).

In most cases the amount of free oxygen available determines the amount and character of corrosion. It is therefore convenient to divide corrosion of iron into three broad classes:

1. **Atmospheric corrosion,** where oxygen is available in large excess.
2. **Underwater corrosion,** where the amount of oxygen present is limited to the solubility of that gas in water.
3. **Soil corrosion,** in which the ratio of moisture to available oxygen varies considerably but where the influence of contact of the metal with dissimilar materials and different electrolytes is likely to be an important factor in accelerating corrosion. This has no reference to the influence of electrolysis from stray electric currents **per se**, which is another problem.[‡]

In this paper the author confines the discussion to the second of these three classes, which includes broadly, corrosion of the interior of pipes, tanks, economizers, boilers and other closed water systems which form such an important part of building, and power plant construction. Before discussing the practical solution of this problem, it may be well to refere briefly to the main factors which influence corrosion

External Factors.

The main factors which control the rate and distribution of corrosion of iron in water (and this applies, generally speaking, to brass and some other metals) are given below in order of importance:

(a) Amount of oxygen in solution.
(b) Temperature.
(c) Quantity and velocity of flow.
(d) Quality of water; presence of one or more electrolytes in solution.
(e) Contact with electro-negative material.

Irregular corrosion, known as pitting, is brought about by contact of the metal with electro-negative materials such as mill scale, brass, copper, but in the absence of free oxygen the influence of all other factors mentioned is insignificant, except where acid is generated continuously, in which case there will be some solution of iron but much less where free oxygen is not present.

Composition of Material.

Before discussing what has been done and what may still be accomplished to conserve such material, it is in order perhaps to answer the question: What may be expected from special treatment of the metal, or what has been done towards the production of a non-corrosive metal suitable for such conditions? A large amount of thought and work has been devoted to this field by metallurgists with some results of note

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[*] Communicated by the author to the Franklin Institute.

[†] "Corrosion of Steel," A. S. Cushman: J. of Franklin Inst., 165, III, 1908. "Corrosion of Iron and Steel," W. H. Walker: I. Am. Chem. Soc., 29, 1251; 30, 473, 1907. "Preservation of Hot Water Supply Pipe," Speller and Knowland: Trans. A. S. of H. and V. Engineers, vol. 24, 1918.

[‡] Report of Committee on Electrolysis, 1921, Am. Inst. of Electrical Engrs.

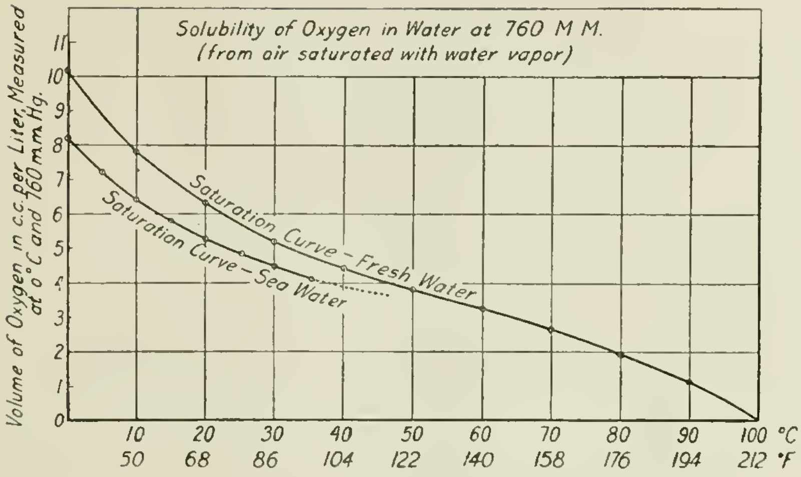

Fig 1.

in the manufacture of special alloys such as monel metal, dur-iron, stellite, stainless steel (high-chome steel), and other alloys, all of which, due to their non-rusting qualities, have useful fields. However, the use of these alloys is unfortunately limited by their high cost and the fact that such metals have not as yet been successfully fabricated for general purposes. So that we must still use such well-known material as zinc, tinplate, brass, copper, wrought iron and steel (uncoated or galvanized) and for most purposes for economic reasons, the choice is usually confined to the last two mentioned. Steel carrying 0.25 per cent copper has proved much better than non-copper bearing steel under atmospheric corrosion, but unfortunately has shown no superiority underwater or underground.

Relative Rate of Corrosion.

In passing, it may be useful to refer to a few of the many comparative tests of wrought iron and steel in water lines which have been made in recent years, for opinions are stil somewhat divided in certain quarters on this question.

The author has previously summarized some of the practical information from experience and tests in service on wrought iron and steel pipe in a paper before the International Association for Testing Materials—1912. Since that time considerable data have been collected from various sources which are summarized in Table I. An extensive series of tests in acid mine water was reported on by Committee A5—A.S.T.M., 1921* The conclusion reached is practically the same from all these investigations, viz., that under water the origin and composition of iron makes comparatively little difference in the rate of character of corrosion. Whatever the influence of composition may be it is apparently small compared with the marked influence of variations in surface finish of the metal, internal strain, contact with other materials which are relatively more electro-negative in character, to say nothing of the predominating influence of other external factors referred to above which, after all, have most to do with controlling the rate of corrosion. Enough has been said to indicate that at present in many cases, we have no choice but to consider means for keeping the water from contact with the metal or to remove the corrosive power of water and thereby render it inactive. Thus corrosion may be prevented or greatly retarded either by means of protective coatings or by removing the free oxygen from water.

Protective Coatings.

Many protective coatings have been devised to protect pipes and other metallic structures under water. These may be divided into (a) non-metallic coatings such as paints and bituminous dips, (b) metallic coatings. The latter may be classified into metallic coatings which are electro-negative to iron and those which are electro-positive. The former include lead, tin, copper, nickel, and protect only so long as the coating is intact, after which the coating metal usually accelerates corrosion and results in pitting. Electro-positive metals include such as zinc, aluminum and certain kinds of brass. Iron is protected by such metals, even though the protective coating does not entirely cover the sur-

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*Proc. A. S. T. M., vol. 21, p. 157, 1921.

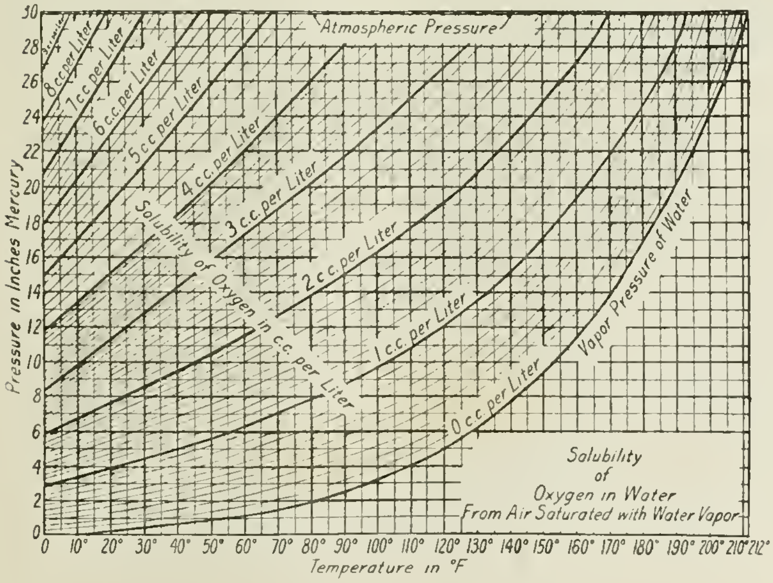

Fig. 2.

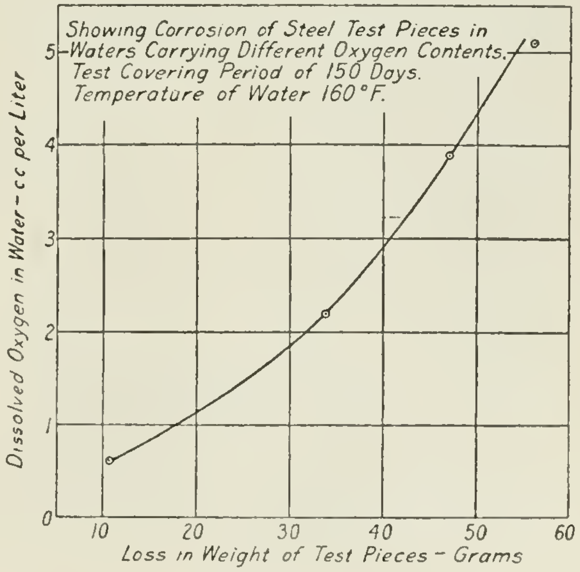

Fig. 3

face, until the area of iron exposed becomes so large as to extend outside the range of galvanic influence of the more electro-positive metal. Zinc coatings on account of their economy and ease of application are most generally used and find a wide and useful application in various forms such as hot galvanizing, electro-galvanizing, Sherardizing and spraying. Each of these methods of zinc coating has special advantages for certain purposes which have been developed by experience.†

There is good evidence that iron and steel acquire under certain conditions a protective film or scale which often has considerable influence in warding off the attack of hydrogen ions in water. Iron or steel which contains over 0.10 per cent copper has a very decided tendency to develop a strongly adhering and more or less impervious coating of rust under atmospheric corrosion, but under water this metal corrodes like non-copper bearing steel, evidently because the rust formed under these conditions does not adhere so well and is more open in its physical structure. Steam pipes which have been in use for many years often exhibit such coatings, particularly where the steam carries a small amount of oil, which results in a protective coating consisting of a mixture of hydroxides of iron and certain oily deposits. The absence of this coating in modern systems fed by steam generated and delivered directly for heating purposes has in some cases resulted in more corrosion than where exhaust steam was previously used. The remedy for this is to reduce the free oxygen and carbonic acid in the boiler make-up water to a minimum, and keep the system tight as far as possible.

Waters of certain compositions throw down a protective deposit of organic or inorganic material on the inside surface of pipe, which has a marked effect in retarding corrosion. It has been observed that some of the domestic waters of New England are more corrosive since filteration has come into more general use.

Another instance of natural scale forming is found where water from the Great Lakes is heated for domestic use or power purposes. A thin scale is usually found on the inside of pipes which carry this water:

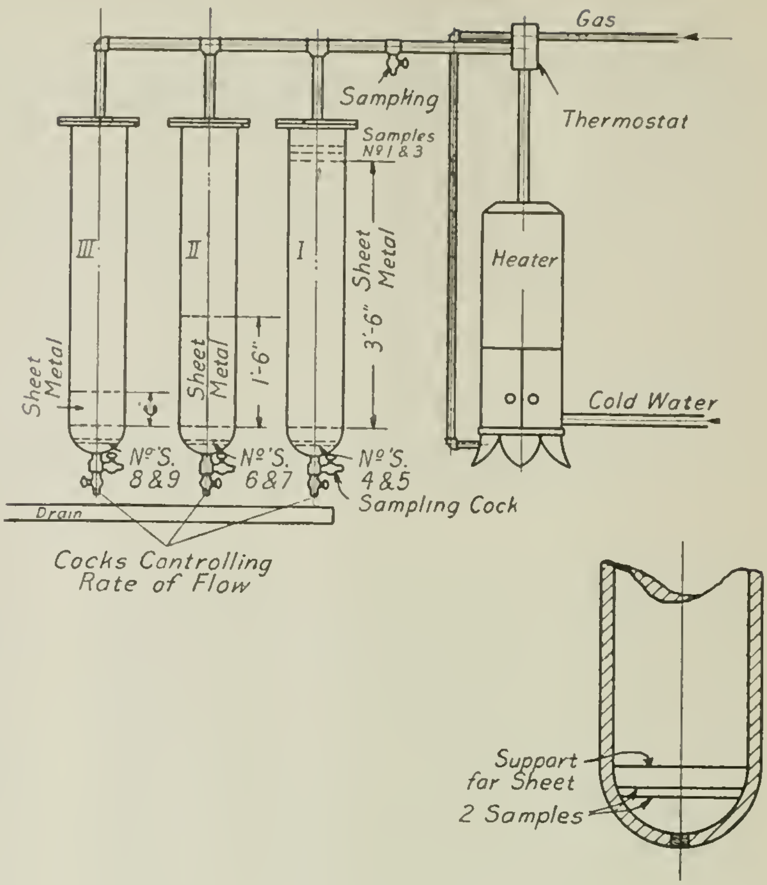

Fig. 4.

Space occupied by sheet metal (26 gauge). Tank No. 1, 33,500 c.c., No. 2, 14,366 c.c.; No. 3, 4,790 c.c.

the average of several analyses of such scales collected by the author gave:

Iron	28.4 per cent
Lime, $CaCO_3$	3.0 per cent
Silica	4.8 per cent

The lime and maganesia are usually present as bicarbonates in these waters, and when heated a portion of the half-bound CO_2 is removed, resulting in precipitation of some of the lime. The silica found in these scales is probably precipitated by reaction with colloid

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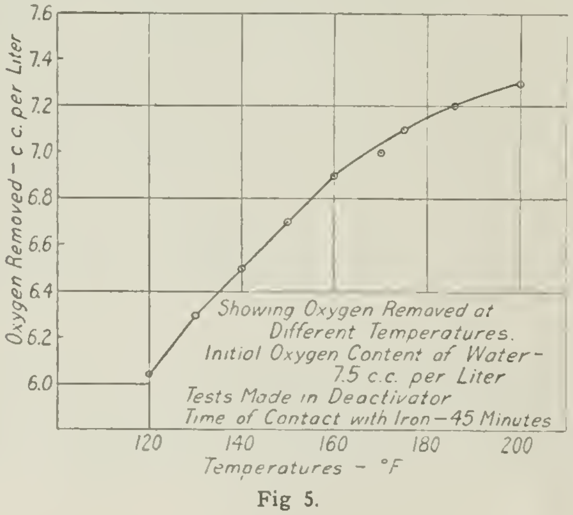
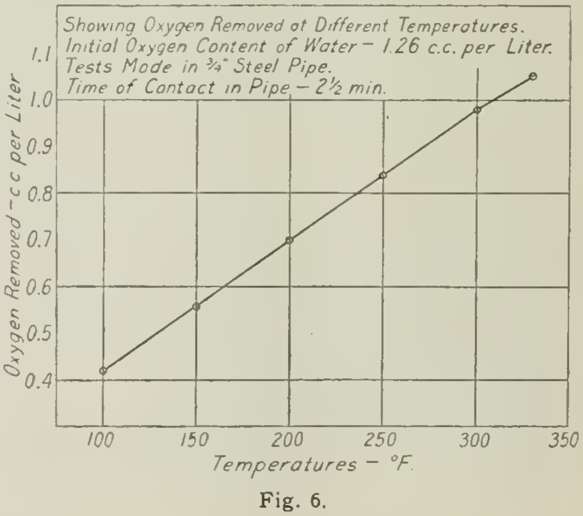
†Bureau of Standards Circular No. 80, "Protective Metallic Coatings for Rust-proofing of Iron and Steel." October, 1919.



Showing Oxygen Removed at Different Temperatures.
Initial Oxygen Content of Water – 7.5 c.c. per Liter
Tests Made in Deactivator
Time of Contact with Iron – 45 Minutes

Fig 5.



Showing Oxygen Removed at Different Temperatures.
Initial Oxygen Content of Water – 1.26 c.c. per Liter.
Tests Made in ¾" Steel Pipe.
Time of Contact in Pipe – 2½ min.

Fig. 6.

ferric hydrate which always forms a large proportion of these scales. The study which the writer has made of pipe corrosion with various domestic waters has shown that there is a marked difference in the life of pipe in certain localities—one of the most noticeable contrasts in this respect is between the rate of corrosion of pipe used in the Great Lake cities where a comparatively hard scale-forming water is used, in comparison with the action of domestic water of New York or New England, which is relatively purer and softer. Generally speaking, hot-water pipes under the former conditions last two or three times as long as in the later, other factors being the same.

It is quite possible that some practical means will be developed to give domestic water this scale-forming property without making it objectionable in other respects. Some research work on this problem has been under way for a year or so in our laboratory, which indicates that while such protection is incomplete compared with deactivation of water, that it is possible to form a coating on the inside of pipes under certain conditions, which will cut down corrosion sufficiently to prevent all but a slight discoloration of the water.

Dissolved Oxygen in Water.

The controlling influence of free oxygen on corrosion in water is clearly indicated by the electrolytic theory and has been repeatedly demonstrated by experiments and confirmed by practical experience (Fig. 3). The solubility of oxygen in pure water follows the Law of Henry, which states that the solubility of a gas at a given temperature is proportional to the pressure of the gas above the solution. Expressed as a vapor pressure law, this means that the partial pressure of a volatile solute from a solution is proportional to its molecular fraction or to its concentration.

The solubility of oxygen in salt and fresh water at atmospheric pressure varies with the temperature as indicated in the chart (Fig. I).

The chart shown in Fig. 2 was prepared by Mr. T. M. Knowland for a report for the National Tube Company from work in the Massachusetts Institute of Technology Research Laboratory and will be found useful for calculating the amount of oxygen dissolved in water from air at any temperature or pressure.

The solubility of iron in water is usually so low that in the absence of oxygen, corrosion is negligible except, as we have pointed out before, where the concentration of H ions is considerable and is maintained by some means, in which case such corrosion cannot be ignored. However, this condition is rarely found in domestic water and but occasionally in water used for power purposes. In these cases the acid or acid-forming compound, which is usually magnesium chloride, may be neutralized by the addition of lime.

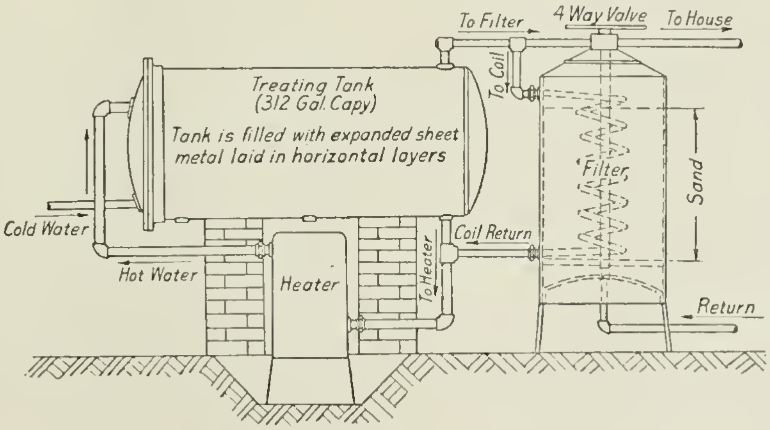


Fig. 7.
Water heater and deactivator for apartments in Boston.

Fig. 3 shows in diagramatic form results of a series of weighted tests of corrosion in water, made under constant conditions but with varying oxygen contents. The water was passed continuously through a series of steel cylinders (Fig. 4), in which were placed varying amounts of perforated steel sheets so that the oxygen content of the water was reduced by stages.

The problem of protection of metal pipes or tanks carrying water is therefore one of removing the free oxygen from the water before it enters the system and preventing further supply of oxygen. To secure practical immunity from attack, it is not necessary to remove all the free oxygen; the amount which may be tolerated depends on the temperature and amount of water passing through the system. For example, a hot-water service system for a building where water is used at 135 deg. will show no serious corrosion with an oxygen content of 1.0 c.c. per litre; at 170 deg. F., to get as good results, the oxygen contents should not be over one-half of this, or 0.5 c.c. per litre; and in the case of a boiler economizer operating at 300 deg. F., the residual oxygen would probably have to be reduced to 0.2 c.c. per litre to reduce corrosion to a negligible amount. There are other factors, of course, which make this estimate only approximate, but as it is a more difficult and costly matter to remove the last one-half c.c. of oxygen per litre from water, the degree of removal required is one of the main considerations in determining the selection of the most suitable and economical apparatus for any particular case.

Oxygen removal apparatus has been developed to a high degree of efficiency in this country during the past six years as a result of various designs which have been worked out in service.

These may be divided into three classes, according to the principles employed:

1. Apparatus for oxygen removal by chemical means.
2. For oxygen removal by mechanical or physical means.
3. Combinations of the above in the same plant.

Oxygen Removal by Chemical Means (Deactivation of Water) In the United States.

We have frequently noticed that in service more corrosion is found near the inlet to a pipe system than farther away; that in boilers there is more corrosion near the feed-water entrance; and that in hot-water heating systems where only a relatively small amount of water is added each season, no serious damage occurs. Such experience and the viewpoint of corrosion given by the electrolytic theory, led the author to experiment in 1906 with the removal of free oxygen from water by means of contact with a large surface of scrap iron for which apparatus was built in the Research Laboratory of the National Tube Company. Favorable results were obtained, but continuous operation of such a long period of time required considerable experimental work on a working scale, and it was not until 1915 that a satisfactory plant constructed on this principle was put into working operation in a building in Pittsburgh.*

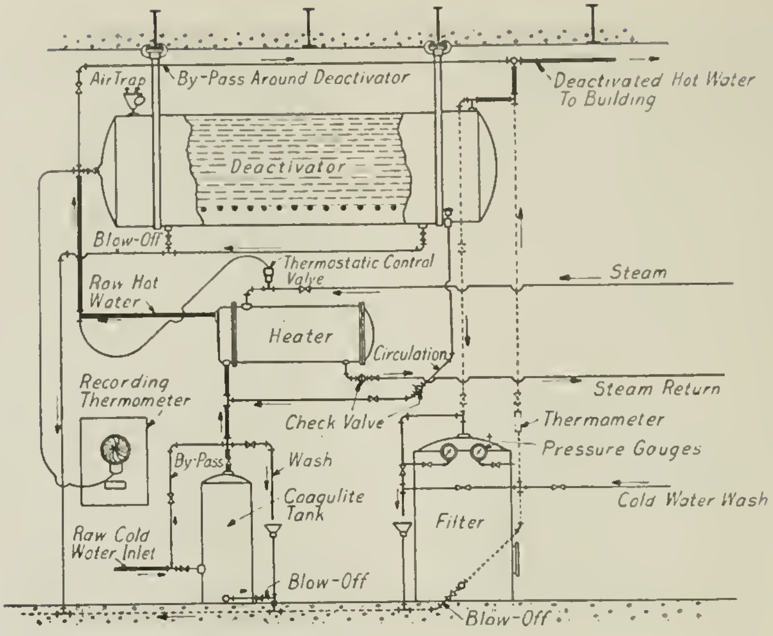


Fig. 8.

Hot water deactivator. Heavy lines indicate course of water when not using filter. Light lines indicate by-passes and other necessary connections.

For lack of a distinctive name, the word "deactivator" was adopted to describe such an apparatus, for water after having most of its dissolved oxygen removed in this way, has been found to be inactive toward iron. The deactivating tank is preferably filled with a special type of expanded steel lathing (about 26-gage), so formed that the individual sheets will not lay so close as to cause excessive resistance to flow. Miscellaneous steel turnings usually rust together in a tight mass in time so as to seriously interfere with flow. Figs. 5 and 6 show the influence of varying temperature on deactivation. The density of the steel, as expressed in square feet of surface per cubic foot of volume, is another important factor affecting the rate of oxygen removal by this method.†

A later form of deactivator installed in an apartment in Boston in 1917 is shown in Fig. 7. A filter was provided in order to secure clear water free from iron hydroxide; the iron found in solution in the filtered deactivated water is usually less than 0.2 p.p.m. Experiments conducted by Dr. W. H. Walker and his associates at the Massachusetts Institute of Technology, Industrial Research Department, on coagulation of iron in deactivated water, developed the fact that by rendering the water slightly alkaline to phenolphthalein, the colloidal iron could be readily coagulated, and that passing water through a slightly soluble form of granular magnesium oxide was a very convenient means for accomplishing this result. This gave a simple and automatic control of coagulation, which materially increased the efficiency of the filter. This experience suggested to the author the possibility of flocculating the hydroxides of iron to such an extent that they would be retained on the expanded sheet steel of the deactivating tank. Experimental work on the influence of temperature, rate of flow, and alkalinity on the production of clear deactivated water, showed that with a certain relation between there factors good results could be accomplished. The most favorable conditions under which clear deactivated water can be obtained in service without the use of a filter have been developed by tests on plants in operation, including the one shown in Fig. 7, which now operates without the filter. Fig. 8 shows the latest form of apparatus for this service in which the filter may be omitted or by-passed as desired.‡ However, the rate of consumption of hot water in some buildings is so variable that a filter may be necessary in some cases in order to secure perfectly clear water at times.

European Practice.

Another form of apparatus for removing dissolved oxygen by use of steel scrap has recently been brought out by Kestner and Paris in Europe and is described in a paper by G. Paris* The novel feature claimed for this is intermittent and reversible flow, based on the assumption that ferric hydroxide is reduced to the ferrous form when allowed to stand in contact with iron and water for some time. Under these conditions the iron hydrates lose their reddish color to some degree, but we have not found them to be more active in this form even after the deactivator has been allowed to stand at rest for 30 hours. Moreover, most of the plants constructed in this country have operated with periods of rest of at least several hours each day with no perceptible regenerating influence, so that while we have found a slow falling off in activity, the deactivator has been found to function for as long as four years without renewal with satisfactory results. The author is inclined to believe that the change in color of ferric hydroxide from red to black on standing is due to dehydration rather than to reduction to the ferrous form. However, in this connection, attention should be called to the fact that freshly precipitated ferrous hydrate removes dissolved oxygen from water with great rapidity compared with iron; for instance, Mr. R. G. Knowland, in our research laboratory in 1918, found that freshly precipitated ferrous hydrate combines with all the oxygen in water at 160 deg. F. in a few seconds, whereas steel sheets packed with surface density of 70 square feet per cubic foot of space required at least 40 minutes' contact to remove 80 per cent of the oxygen at this temperature. The advantage of the steel sheet method, however, is that it is entirely automatic and will operate for two years or more in a properly proportioned plant without more than casual attention by unskilled help.

A type of deactivator very similar to some of those which are in operation in this country has been brought out recently by the Metropolitan-Vickers Electric Company of England and another by Hulsmeyer in Germany for power plant purposes, but so far as the records go, none of these have been put to more than very limited use as yet.

(To be continued next month.)

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*Described by the Author as "A Method for Practical elimination of Corrosion in Hot Water Supply Pipe," Proc. A. S. H. and V. Engineers, vol. 23, 125, 1917.

†U. S. Patents No. 900,323, No. 1,204,602, No. 1,274,099 (F. N. Speller) refer to the application of this principle to the removal of free oxygen from water.

‡"Les Corrosions Du Fer et leur Suppression par le Dégazage de L'eau," Chimie et Industrie, vol. 6, No. 1, July, 1921.

The Joy of Being a Chemist

By D. M. STRICKLAND
Research Engineer, American Rolling Mills Company

CHEMISTS have discovered not only some eighty-odd formulae for home brew production, but also that all matter is made up of varying proportionate amounts of some eighty-odd elements. They further declare that each element, when divided into its smallest existible size, produces atoms. Thus, we have atoms of lead, mercury atoms, oxygen atoms, iron atoms and so on through the list. In fact, it is correct to say that all matter is made up of atoms; atom being being the family name, so to speak, while the eighty-odd individual names characterize the family members.

"Atoms are little, firm, hard balls" is the statement I found one time when grading chemistry students' quiz papers. This definition amused me. I put a big blue ring around it and wrote an ironical marginal notation. Yet, the student was not far from the truth. There is no doubt but that atoms are little. Just call to mind the smallest thing you can imagine, divide it into a few million parts and perhaps you will have estimated the size of a member of the atom family.

If you interpret "firm hard" to mean tenacity on the part of the atom to hold its individual physical and chemical characteristics, the inability of human manipulative skill to divide it or change it into other elements — then, the above definition is plausible. A scientist would say, "Atoms (Greek meaning indivisibles) are, since matter is incapable of indefinite subdivision, the ultimate particles resulting from ideal separation.' I'll leave it to your judgment which definition suits your taste.

An inestimable number of atoms must exist side by side before we have a visible quantity of an element. Take a chunk of iron the size of your fist and, if you are spending a few years idle time waiting for the next Democratic administration, hold it before your eye and try counting the number of atoms you imagine the piece contains. Or, if you suffer from insomnia, take it to bed with you and count: atom one—atom two—atom—ato—at—a—etc.—much more up-to-date and scientific than counting sheep as they hurdle the fence.

When two or more different atoms join partnership and enter a state of chemical union, a molecule is formed. It only takes a few billion similar molecules to form an appreciable quantity of a compound. For example, sodium atoms unite with chlorine atoms to produce sodium-chloride molecules. Now, sodium chloride is nothing more or less than common table salt; that white crystaline substance which pours out of the June bride's silver-plated saltcellar and is blasted out of such antideluvian queensware shakers as are found in restaurants, cafeterias, and boarding houses.

Iron in its original elementary state belonged to the atom family—that inner circle—the staid old group of 80.

Unfortunately, however, for the human race in general (but to the decided financial betterment of the iron and steel business in particular) it turned out to be one of the black sheep of the family. Refusing to live up to such high standards as did its more noble brothers, gold and silver, it united with various other elements to form compounds. So iron atoms joined oxygen atoms forming iron-oxide molecules—or, generally speaking, iron ore.

This good old ore lay undisturbed while men of the paleolithic age fought with stones, hunted with flints, wooed with clubs, shuddered at lightning, and gave up the ghost. No human hand disturbed the ore during the stirring times when the armies of ancient history spanked each other with bronze spears, copper shields and brass knucks. So man advanced through the stone age and bronze age; acquired more knowledge and lawyers — more politics and prohibition — more science and patent medicines—and, finally, more need of this article which shows how important a part the chemists have taken in winning iron back to the original atomic family after centuries of molecular wanderings and backslidings.

The purification of iron ore is no simple matter. To separate iron from the elements with which it has existed in chemical combination for ages and ages is not an easy task. In fact, those who are not familiar with steps necessary for the manufacture of commercially pure iron will be surprised at the number of purification rounds which must be fought before the clinging impurities are knocked down and out.

Stamp vending machines, jazz records, Bolshevism, Jimmy Cox's presidential race and the economical production of commercially pure iron are all developments of the twentieth century. To produce iron which conforms to purity specifications, it is imperative that the contaminating impurities be present in traces only, say to an aggregate amount of less than one-fifth of one per cent. Now, one-fifth of one per cent means that Casey must come to bat some five hundred times for a total of one hit. An out-fielder with an average like that wouldn't be permitted to play ante-over at an old maids' home.

Iron ore contains approximately 55 per cent iron and 45 per cent impurities. The best grade ore is found in the Lake Superior regions. First, it is mined, generally by stripping off the upper soil stratas and digging out the exposed mineral. Very simple, just like taking the lid off of a nut and picking out the goodies. The ore is transported to manufacturing centers by rail and ship. The ship loading and unloading facilities are monumental examples of human achievement and inventive ingenuity. Thousands and thousands of tons of ore are handled each year with as much ease as a drunken sailor handles money.

The first purification process is the reduction of ore in blast furnaces. The ore mixed with weighed amounts of coke and limestone skips up the hoist and jumps into the top of the blast furnace stack, the skipping and jumping being accomplished by a generous application of pulleys, ropes, bucket cars, and sundry other mechanical devices.

Superheated air is blown into the stack by means of tuyere pipes leading into the furnace at a height of about 10 feet from the ground. Vast volumes of this superheated air are blown into the furnace every minute, a regular Senatorial blast in fact. Within the stack, the coke burns, the oxygen atoms are separated from the iron atoms, the charge melts, the drops of iron trickle down to the hearth at the bottom while the lighter liquid impurities float on top of the molten iron. From time to time the metal is tapped out of the furnace and run into moulds where it solidifies. This product of the blast furnace is commercially known as pig iron.

The slag or liquid impurities when run out of the furnace become the source of livelihood for waste product engineers. Studying the what-to-do-with-blast-furnace-slag problem has brought the $3,000 a year to many an efficiency expert and the sum total of their conclusions indicate that slag can be economically used for paving materials, mineral wool, cements, and ballast for Henry's D. T. & I.

Pig iron usually contains from 5 to 8 per cent impurities. It is an intermediate product obtained in the iron and steel manufacturing process and is used for remelting purposes only, having no other value except as a producer of revenue for blast furnace owners. Further purification of pig iron is usually accomplished by either the Bessemer or the open hearth process. Commercialy pure iron is made in open-hearth furnaces; the product of the Bessemer process being steel which generally varies in iron content from 98 to 99 per cent. Ordinary irons and steels are also made in open-hearth furnaces, but these products do not require such exacting manufacturing care as is necessary for purity iron production.

The manufacture of pure products is always attended with difficulty. The development of satisfactory purification processes requires careful experimental testing, scientific experience, and a thorough knowledge of the accomplishments of preceding generations of investigators. This is true, not only for iron, but for zinc, copper, lead, and metals in general. It is equally true for soaps, gasolines, paints, oils, cosmetics, foods, beverages, and life's necessities as a whole. Although it increases production costs, yet, American buyers demand that their purchases conform to ridged purity qualifications. Chautauqua circuits demand Bryan as it is universally known that William Jennings drinks only the purest grape juices obtainable. Even Michigan demands the best politicians money can buy.

The blast furnace pig iron when mixed with scrap iron and limestone is charged into the open-hearth furnace. In the good old days when saloons had a front as well as a back entrance, this charging was done by hand and a gruelling, back-breaking job it was, too, but now the materials are weighed up in pans on buggies and run up in front of the furnace doors where a charging machine grabs the pans and dumps the contents on the furnace hearth. Artificial or natural gas burns across the furnace above the charge and produces a temperature several degrees warmer than a front seat in Billy Sunday's tabernacle.

After several hours the iron and purifying flux melt down and are ready to tap. Right now, however, is where science steps in. When open-hearth melts are tapped at this point, the resulting product is not pure enough so a departure from the usual manufacturing procedures is necessitated. The chemists, those wizards who can tell you how much cotton is present in a $9.98 all wool suit, now come forward and contribute their efforts and knowledge toward reducing the remaining traces of impurities to a minimum—that one-fifth of one per cent mentioned above.

I used to juggle test tubes in an open-hearth laboratory. I soon learned what it meant to hold a hundred tons of molten iron in the furnace while the final purification was accomplished. I recall one sizzling hot July afternoon about three weeks after I started to work. While I was creating a whirlwind of useless laboratory activity in an effort to impress my superiors that a college man might possibly amount to something after all, an open-hearth furnace helper brought me a preliminary test. He was a typical furnace man; a big, strong, good-natured, hard working foreigner. His undershirt, trousers, and shoes were soaked with perspiration. His blue lensed furnace glasses were pushed back on his forehead and a bandage on his arm located the most recent hot metal burn. After handing me the test he drank a quart of water, sat down, and wiped his face with a handkerchief in which overall blue was the prevailing color.

I knew that a preliminary test was a spoonful of metal diped out of the furnace. I also knew that the men were working with the molten iron in the furnace, awaiting the results of my analysis, and hoping that the impurities would be low enough that no more delay would be necessary. I tested the sample as rapidly as possible. When the results were obtained I turned to the foreigner and said:

"John, you will have to bring another test."

"Whazzamat? Too mooch sulphur?"

"No, sulphur is low enough—copper and phosphorous are all right—too much manganese."

"Too mooch magnas? Hell!"

Never had I heard that simple expletive delivered with more feeling. The results of my analysis meant that he and his companions had to work in front of the furnace doors throwing additional purifying agents into the boiling iron and continue to do so until subsequent tests and analyses showed that the metal conformed to specifications. No wonder he was moved to violent expression.

Long haired poets sit along the sea shore, musing in iambic pentameter measurement and wondering what the wild waves are saying. Stock brokers and millionaire cooks, motorists and flivverettes, artistic tempermentalists and sensible citizens wander all over the Garden of the Gods, Yellowstone Park, and the globe in general, audibly expressing their conceptions of the beauties of nature and wondering what the next head waiter will think when he gets his tip. The bowery pawnbroker and his family enjoy a Coney Island boat trip, callisthentically tickled that little 10-year-old Isaac got through the gate for nothing and wondering whether they put the cat out and locked the back door. And so it goes. Everybody, everywhere, hunts for novel amusements, new scenery, and nature's wonders.

Let me give you an idea. The next time you feel the need of a beautiful and wonderful sight, something out of the usual humdrum existence—take a trip to the nearest open-hearth furnace plant and watch the tapping of a heat. You will be well repaid for your trouble.

Witness a hundred tons of white-hot molten iron running out of the furnace down the trough and pouring into the brick-lined ladle; long tongues of flame leaping higher and higher; scintillating sparks shooting up, out and every which way. Watch the ladle fill to the brim and see the liquid slag swirl and dart and boil on the top of the metal, finally overflowing with a second display of sparks into the slag pot. Realize the consequences of a false step on the part of the men who open the tap-hole and hover about the flowing metal; metal which would snuff out their lives in the twinkling of an eye. Listen to the roar of the falling iron, the grinding of gears and wheels, the hoarse shouts of foremen. Wonder at the precision-like efficiency of the controlling machinery. Watch the gigantic crane hook onto the ladle and lift it as if a feather, carrying the tons of molten metal to the mold train, losing along the way such metal as overflows the top and falls to the ground in a veritable shower of brilliants and diamonds. Now, double the beauty of the whole spectacle by choosing a midnight hour and let the inky darkness of night give a contrasting background against which the sparks and flames and fires will shine out in all their radiant splendor.

After you have witnessed the tapping of a heat you are qualified to talk scenery with anybody. Call to mind that old bore who lives around the corner. You remember he went to Niagara Falls on his wedding trip 40 years ago. He never forgot it or permits anybody else to forget it. Hunt him up and say:

"Neighbor, did you ever see an open-hearth furnace tap?"

"Naw. But I DO remember what I saw about 40 years ago, etc.—'

Now, crush him. You have the ammunition.

The bubbling iron is held within controllable bounds by humanly devised machanisms. Before tapping, it is held in check while the chemist demands of science, "Is it pure enough?" Then its great to be a chemist. You are the whole show at this stage of the manufacturing process. You're responsible. Before pure iron can be produced, you are a vital factor—you must contribute something—you must use your ability and skill. The superintendent as well as the furnace helper stands around and waits for you to say, "Yes" or, "No."

When the analyses are completed and science is satisfied—while you watch the metal pour out of the furnace—you have that enviable feeling which comes with a realization that work is well done. You have a feeling of accomplishment, a desire to tack a sign on your back which says, "I've done something. Look at me," and then parade around in front of kings, princes, and presidents; before relatives, friends, and strangers—anybody—anywhere.

Reducing the Cost of Handling Coal

Statistics Showing a Saving of Cost of Handling Bulk Material by the Use of Better Belt Conveyor Idlers.

By J. M. KELLY*

IN the handling of coal, coke, ore, limstone and other bulk materials about a plant, belt conveyors are fast coming into more extended use. It is important to secure uninterrupted conveyor operation at the lowest cost per ton, and careful consideration of the type of troughing and return idler bearings is therefore well worth while.

In computing the power required to drive a belt conveyor delivering a certain tonnage at a given speed, various formulae are used, but the most general is:

$$\text{Power} = \frac{\text{Constant} \times \text{Capacity} \times \text{Length}}{990} + \frac{\text{Capacity} \times \text{Lift}}{990}$$

The constant depends on the belt width and the weight per cu. ft. of material handled.

The capacity is expressed in tons of material per hour.

The length is the distance between centers of head and tail pulleys expressed in feet.

The lift is the vertical distance through which the material is lifted and is expressed in feet.

For this formula various authorities give the value of the constant as .138 for a 48-in. belt conveyor handling coal which weighs 50 lb. per cu. ft. when plain bearings are used.

A recent test was conducted on a belt conveyor, the troughing and return idlers of which were equipped with anti-friction bearings of the flexible roller type.

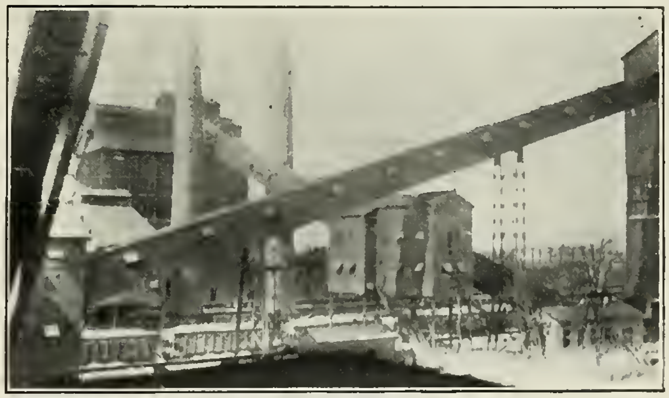

Fig. 1.—View of conveyor at the new by-products coke oven plant of the Donner Union Coke Corporation at Buffalo, N. Y. This conveyor is equipped with Hyatt Roller Bearings.

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*Engineer with Hyatt Roller Bearing Company, Pittsburgh, Pa.

Of course the power required to elevate the coal through the vertical distance will remain the same regardless of the type of troughing and return idlers, but the friction horse power, which is for the most part the power required for the belt to overcome friction in the idlers, is materially reduced by the installation of efficient bearings.

The specifications and measured factors on the conveyor tested are as follows:

Belt Width	48 in.
Length	404.5 ft.
Lift	119.13 ft.
Measured Speed	505.6 ft. min.
Measured Capacity	1,020.52 tons hr.

Substituting these items into the above formula the power required to drive the conveyor when equipped with plain bearing idlers would be 180.34 hp. Of this power, 122.8 hp. is required to lift the coal through the vertical distance of 199.13 ft. while 57.74 hp. would be the friction consumed in the idlers. The constant of .138 which was checked on other 48-in. conveyors equipped with plain bearings would be used in this calculation.

Fig. 2.—This long roller bearing equipped conveyor is reducing power and maintenance items of an important steel company in the Ohio Valley.

However, the actual power required to drive this conveyor which was equipped with the anti-friction flexible roller bearings was only 148.4 hp., 122.8 hp. of which was used to elevate the coal through the vertical height and 25.6 hp. to overcome the friction in the idlers.

This represents a saving of 31.94 hp. in favor of the anti-friction bearing equipped idlers.

The saving made possible by the use of roller bearing idlers on this conveyor is 55.5 per cent of the power required to overcome friction.

Hence the constant to be used in the calculation of power requirements of a flexible roller bearing equipped conveyor 48 in. wide would be .0614 instead of the .138 used for the plain bearing conveyor.

Not only does this reduction in power mean a power saving, but it also means a reduction in the number of belt plies which need be used in order to operate economically and with assurance of long life for the belt. The reduction in power permits a reduction in total tension, because:

$$\text{Tension} = \frac{\text{Power} \times 33{,}000}{\text{Speed}}$$

As the maximum tension is reduced on account of the reduction in power, the unit stress per inch of width per ply remaining the same, a reduction in the number of plies of belt is effected.

This reduction in the number of plies of belt effects a saving in the first cost of the belt as well as in the cost of replacement when the belt is no longer considered useful for conveyor service. The life of the belt of course varies and is estimated between four and five years.

In addition to these economies in conveyor operation made possible by the use of flexible roller bearings in the troughing and return idlers, definite savings can be made in the cost of lubrication, material and labor to apply it. Idlers equipped with bearings of the flexible roller type require lubrication only twice each year, because a reservoir for grease is established within the bearing, and all surfaces are continually lubricated. Belts do not wear out prematurely, due to improperly lubricated idler pulleys, and the continuous service, which is assured from easy turning idlers, is worthy of special attention.

These economies about a steel plant are nothing new, since in many plants similar economies in maintenance, upkeep, power consumption and lubrication costs have been effected by roller bearings on mill tables and cars for several years past.

Tests on other plain bearing and flexible roller bearing-equipped conveyors of various belt widths have been conducted and the power constants to be used in the general horse power formula have been determined.

In the design and construction of new belt conveying equipment these items of power saving, maintenance and increased life from the equipment are being given more attention. The available data from tests of belt conveyors of various widths can be advantageously used in designing new conveyors so that uninterrupted conveyor operation at the lowest cost per ton can be assured from the start.

PURDUE MAN AIDS 57 FOUNDRIES IN STATE

During July and August R. E. Wendt, of the Engineering Staff of Purdue University, visited 57 foundries of Indiana and interviewed 100 foundrymen in an effort to help them solve their problems. Mr. Wendt is an expert of extensive practical experience, and teaches foundry work in the Purdue University Engineering Schools.

The plants visited were very appreciative of the engineering extension work offered by Purdue and were delighted that this work has now been extended to the foundries of the state. Many of the foundrymen were in favor of holding a conference or meeting at Purdue University next spring.

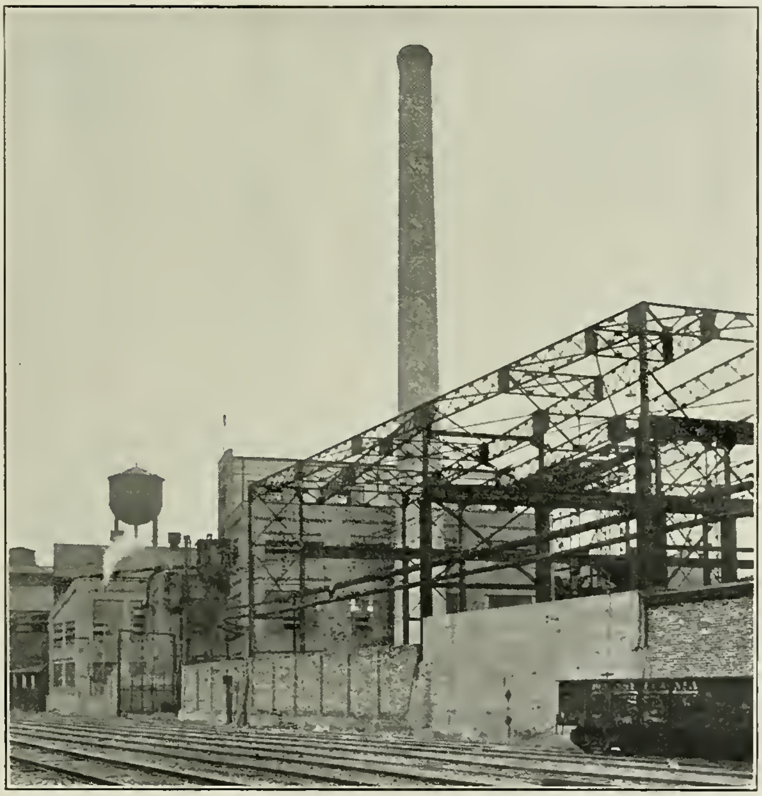
A number of the foundrymen expressed their willingness to take Purdue students into their plants during the summer vacations.

Modern Steam Generating Plant

The Heppenstall Boiler Plant Is Modern and Up-to-Date in Every Detail—It Has Been Designed to Meet Special Requirements Due to the Location of the Plant and to Unusual Service Demands.

BY R. F. KEIFER*

A WORD picture of the works of the Heppenstall Forge & Knife Company would not be complete without a description of our steam generating or boiler plant and, assuming this to be an interesting subject to engineers and operators, we will endeavor to describe the same in detail.



EXTERIOR VIEW OF MODERN STEAM GENERATING PLANT

This illustration gives a good idea of the location with respect to the railroad and of the relative position of the boiler house, chimney, coal handling and crushing equipment.

For several years the proposition of utilizing the waste heat from the forge furnaces for the generation of steam power was given careful consideration, and it was only after due deliberation and a thorough trial that this scheme was discarded and the isolated and scattered units, making up our steam producing equipment, were superseded and replaced by the present splendid and centralized plant.

As is the case in all industrial plants when located in the heart of a thickly populated district, the question of available space is a serious one and the plant must be designed to not only give maximum efficiency, but must do so in the minimum amount of space, bearing in mind at all times the requirements of the particular plant in question; this of course covering the question of receiving and handling coal and the disposal of ash.

Description of the Building.

In general, the building is 47 ft. wide and 85 ft. 4 in. long—inside measurements—of steel framework and brick walls. The building is divided into two bays crosswise and four bays lengthwise and is provided with a lean-to at one end approximately 19 ft. square. The building is also provided with a basement, the floor level of which is 15 ft. below the boiler room and 6 ft. above general yard level.

The two bays, into which a cross section of this building is divided, are designed so that one bay contains the coal bunkers and the other bay will accommodate the boilers. All building foundations extend 3 ft. above basement floor level, resulting in a very pleasing effect of a 3-ft. concrete belt course below the brick walls.

The structural steel framework consists of three rows of two columns—two rows extending to a height of 53 ft. above the basement floor level and were designed to support the coal bunker and monorail and roof above the coal bunker. The rear row of columns extend to a height of 49 ft. above the basement floor level and are designed to support the roof.

A monitor of structural steel has been provided approximately 17 ft. 6 in. from top strut of coal bunker to under side of room beam, and designed suitable to support a mono-rail track with telpher and a loaded 1⅝ cu. yd. bucket. This monitor is approximately 19 ft. wide and is equipped with a structural steel walkway on one side, across one end and for one bay 23 ft. 8 in. long on the other side to give access to the mono-rail crane for repairs and inspection.

The center row of columns is in line with the front of the boilers, and were designed of sufficient strength to carry a heavy girder suitable for supporting the boilers.

The floor is reinforced concrete, designed to carry a superimposed load of 200 lbs. per sq. ft., and all openings through the floor were located previous to pouring the concrete and suitable thimbles "cast in place." This feature assures a finished appearance and does away with the possibility of the concrete spalling off the corners from time to time. Stairways are suitably protected by curb angles and hand rails.

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*Chief Engineer, Heppenstall Forge & Knife Company.

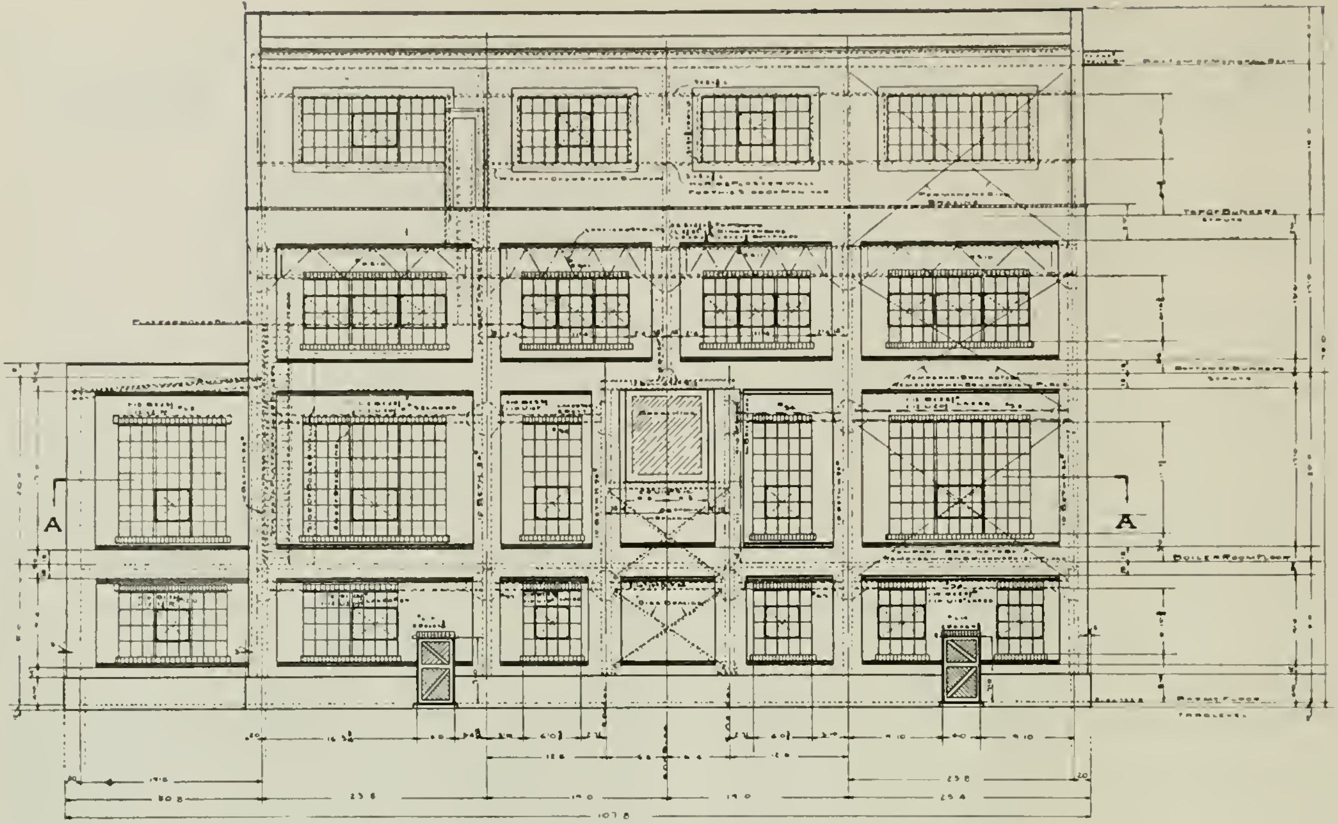


FIG. 1—SOUTHWEST ELEVATION OF BOILER HOUSE AND PUMP ROOM ANNEX

This plant is well lighted, as is readily appreciated when the number of doors and windows is noted. The ventilating sash located in the center of the windows has also proved highly satisfactory.

Brick walls 13½ in. thick, properly pilastered, have been provided, enclosing all structural steel. Brick walls are carried above the roof line to form a parapet and a coping of vitrified tile is placed thereon. The window sills are brick laid on edge. The side wall of the monitor above the main roof is stucco applied on metal lath. Ventilated steel window sash have been used throughout and rolling steel doors have been provided to permit ease in handling large equipment. The arrangement of the windows, doors, etc., is clearly shown on Fig. 1 and Fig. 2.

Coal Bunker.

The coal bunker is approximately 19 ft. wide, 17 ft. deep and 85 ft. long and consists of two inclined longitudinal steel girders, secured to the building columns; these girds in turn furnish the support for a series of steel suspension members supporting the suspension bunker, which is lined with concrete and reinforced with wire mesh reinforcement. The bunker is also provided with eight 12-in. square rack and pinion type gates, operated by means of chain and chain wheels from the boiler room floor, and suitable spouts are also provided to carry the coal from the bunker to the stoker hoppers. The capacity of this bunker is about 700 tons of coal and the clearance above the boiler room floor is approximately 20 ft. This is clearly shown in cross section on Fig. 7.

The roof is a "poured in place" slab of gypsum, reinforced with galvanized steel wire and was installed by the H. H. Robertson Company; the gypsum deck was waterproofed with Johns-Manville 3-ply prepared asbestos Phoenix roofing and when installed was one of the first such installations, and after almost four years' use we have had no reason to regret our decision. It sometimes becomes necessary to extend special piping, etc., through the roof of a boiler house and the construction adopted lends itself readily to such treatment, for this deck can be easily cut with a hand saw and a neat and "finished" appearance is the result.

A structural steel walkway has been provided above the boilers, carried by brackets on the center row of columns; this walkway is reached by a structural steel stairway from the boiler room floor below. From this walkway access to the walkway above the bunker is had by means of a suitably guarded steel ladder. All stair treads and walkways are of "Irving subway grating," Irving Iron Works Company, as a safety measure. This material will permit no accumulation of dirt and has been adopted as a "standard" for use throughout the works.

Coal Handling Equipment.

For the purpose of carrying the railroad coal track over the concrete pit, track girders designed for coopers E-50 loading with 25 per cent allowance for impact were installed.

If we refer to Fig. 3, we note that starting at the far side of the concrete coal pit and extending to the front wall of the boiler house, a structural steel trestle and mono-rail track have been provided to accommodate a Sprague Combination No. 1831-GB-7, 220-volt, d.c. grab bucket mono-rail crane with enclosed cage and Hayward clamshell Class "E" bucket of 1⅝ cu. yds. capacity.

Maximum hoist is 85 ft. from bottom of I-beam track to bottom of bucket; hoisting speed 150 ft. per minute; traversing speed 350 ft. per minute.

Many different types of equipment were considered for handling coal and ash and finally this system of monorail crane and grab bucket was adopted, and three years' operation have proven the wisdom of this decision, there being practically nothing to get out of order, the upkeep is very low and "breakdowns" almost unknown. This equipment is of such capacity as to readily take care of our requirements, a 50-ton car of coal can be stored in the coal bunker in about three hours by one operator, who, also with the same equipment, loads ashes for carload shipments.

Fig. 4 shows the design and typical details of the structural steel trestle, which is 68 ft. from column base to underside of I-beam track, column bases being 6 in. above yard level. Each bent is constructed in general as shown in Fig. 4 of two columns with suitable cross bracing at the top and properly braced longitudinally so that the structure will not be subject to undue vibration under the load of the traveling crane. As shown on the drawing the mono-rail is supported from the cross framing at the top and was designed to carry the loaded bucket and crane with a safety factor of 7½.

Immediately at the side of the track hopper, toward the boiler house, a steel structure has been provided to carry a bin approximately 11x13 ft. together with a coal crushing and screening outfit, the top of the bin being approximately 40 ft. above yard level. For feeding coal from the hopper to the crusher, a reciprocating steel plate feeder approximately 8 ft. long is used.

Coal Crusher.

The Heyl & Patterson coal crusher has two 24x24 in. Cornish tooth rolls and is of 35 tons run of mine to 1¼ in. capacity per hour, being driven by a 25-hp. G. E. motor. All coal crushers have one roll cushioned on springs to permit the roll to move back to pass unbreakable material, but this crusher does not have the adjustable roll gear driven as is most common, but the adjustable roll is driven from a countershaft through belt transmission, the belt being equipped with automatic tension pulley.

Arrangement for adjusting and driving the rolls will permit the space between rolls to be varied and fixed as desired, and at the same time will permit the adjustable roll to automatically move back the full depth of spring compression in case any unbreakable material be accidently delivered to crusher, mixed with the coal. With 1¼-in. space between rolls the adjustable roll may move back 4¾ in. to pass unbreakable material.

Beneath the crusher and supported by suitable framework a screen has been provided for the purpose of separating fine and coarse coal. The fine coal passing through the screen will be diverted by means of a steel chute to a pit, centered under the mono-rail. The coarse material passing over the screen is diverted by a chute at the end of the screen to an adjacent pit under the mono-rail. The crusher is located beside the steel trestle in a

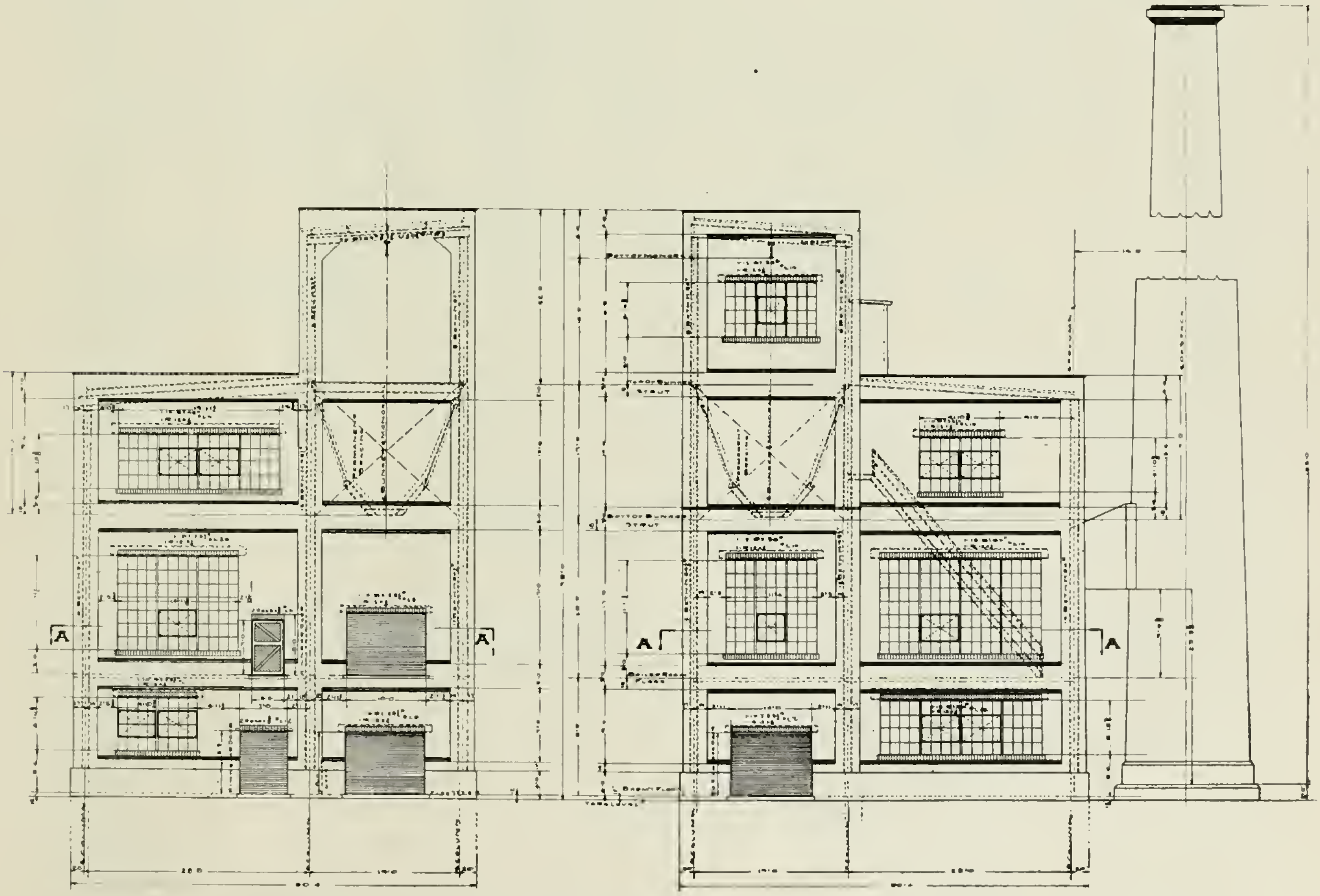


FIG. 2—NORTHWEST AND SOUTHEAST ENDS OF BOILER HOUSE

Arrangement of doors, windows and ventilating sash is shown and the position of the coal bunker is also indicated.

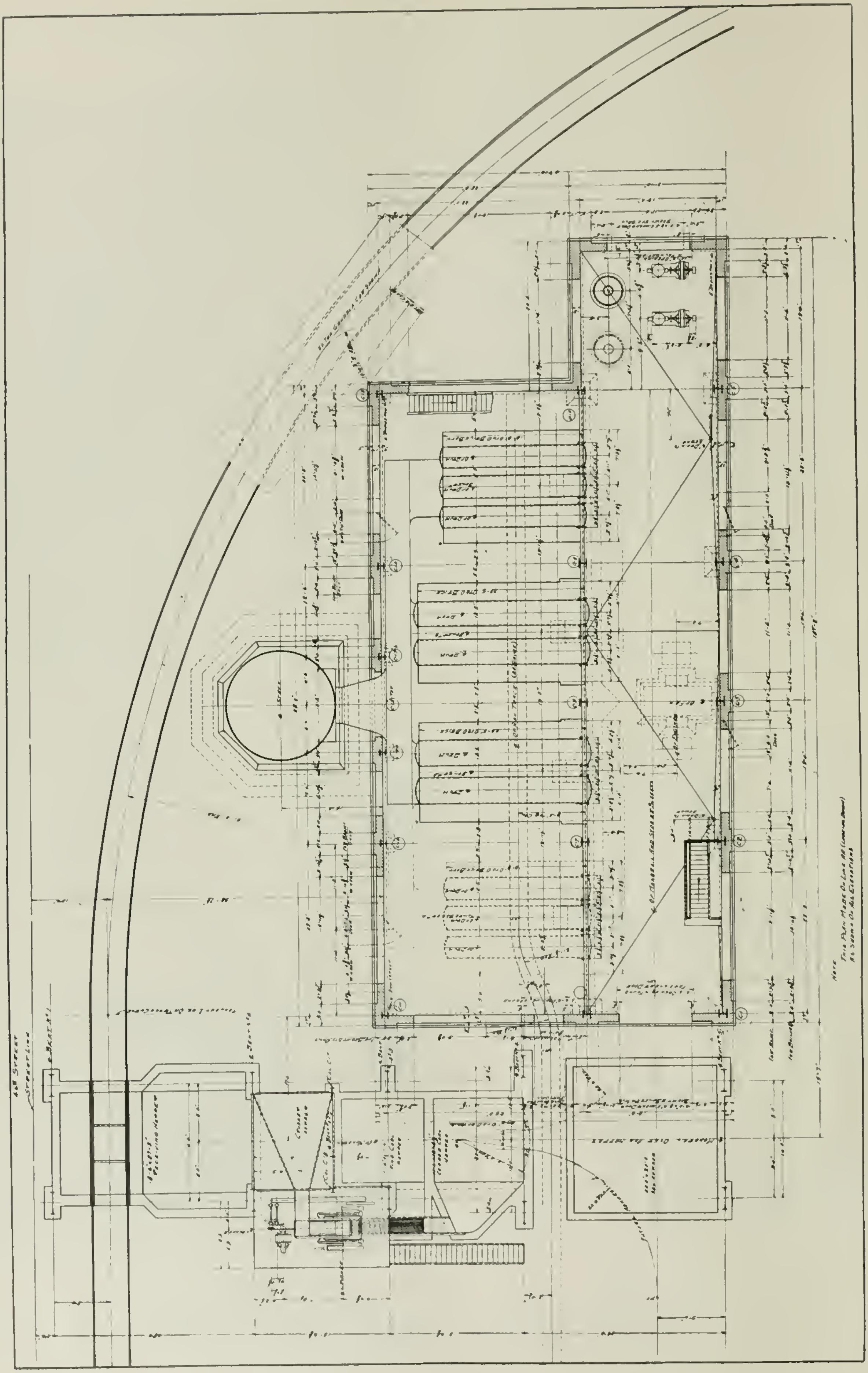


FIG. 3—PLAN OF STEAM GENERATING PLANT OF HEPPENSTALL FORGE & KNIFE COMPANY

Location and arrangement of the coal handling, crushing and storage equipment together with the position of the boilers themselves in the boiler house are indicated. The railroad siding serving this unit is also shown.

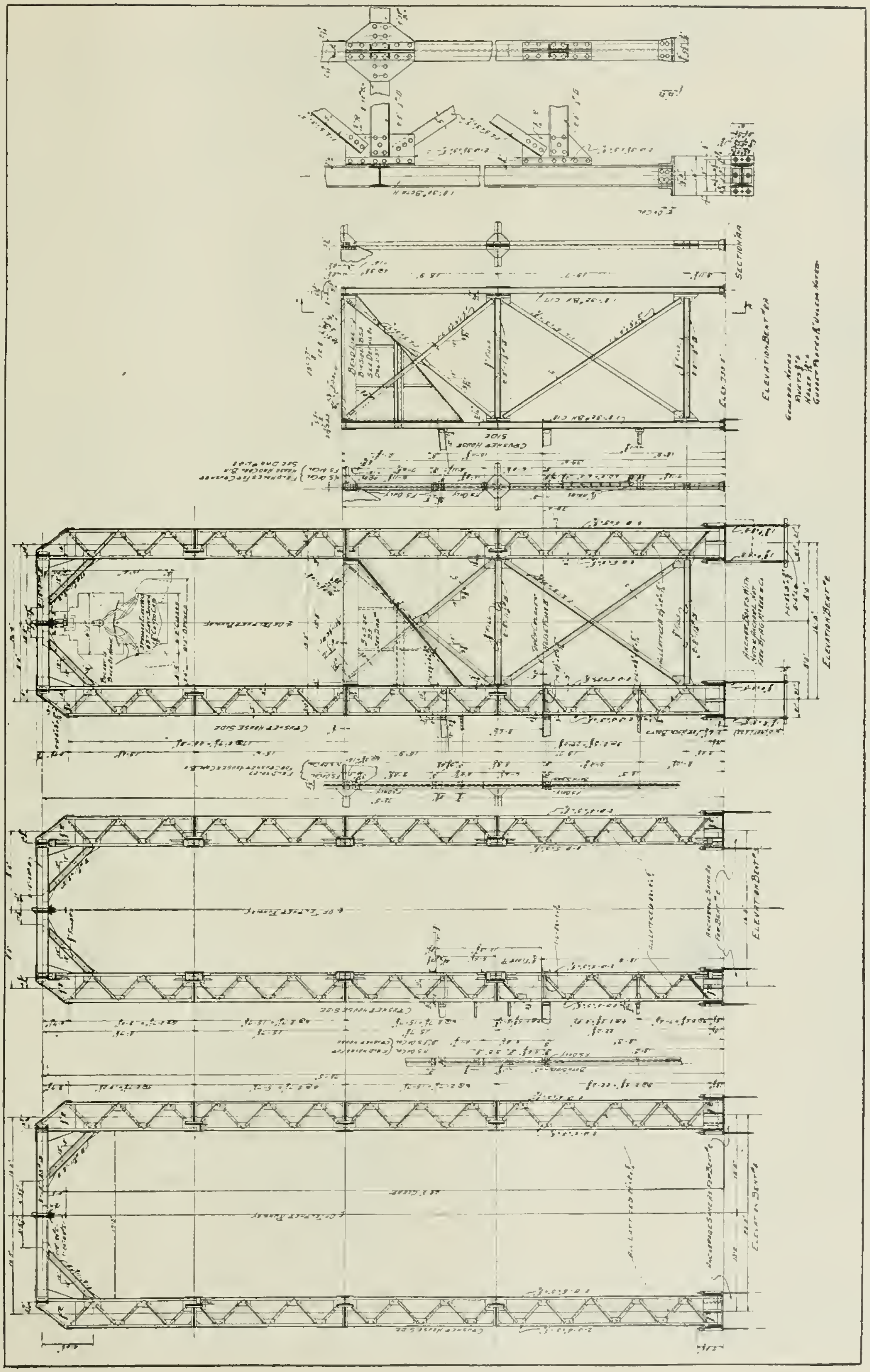


FIG. 4—DESIGN AND TYPICAL DETAILS OF STRUCTURAL STEEL TRESTLE.

Each bent is constructed in general of two columns with suitable cross bracing at the top and properly braced longitudinally so that it will not be subject to undue vibration under the load of the traveling crane. The monorail is supported from the cross framing at the top.

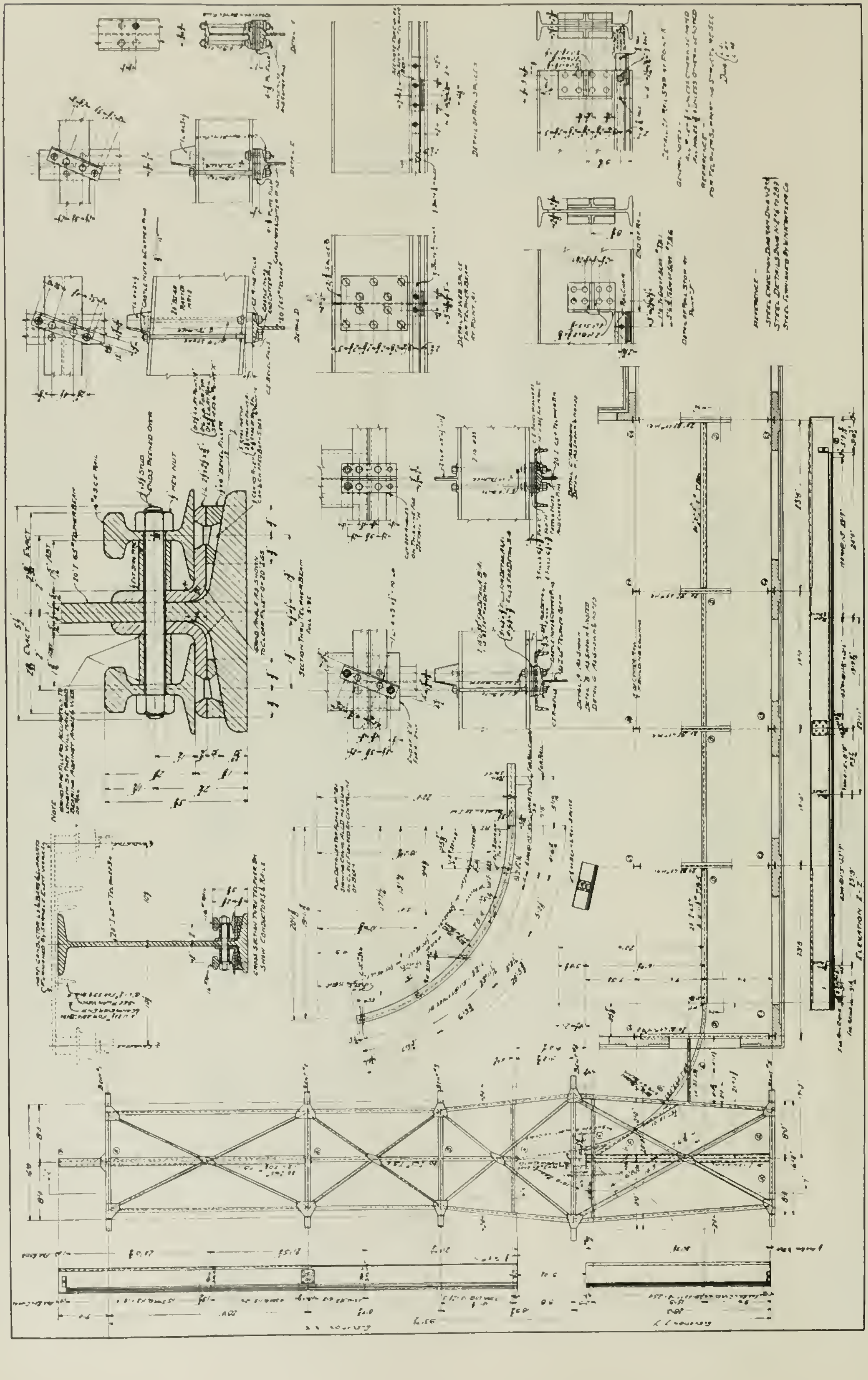


FIG. 5—DETAIL OF MONORAIL FOR STRUCTURAL STEEL TRESTLE

Including a number of detail plans showing the top construction of the trestle, the telpher beam and conductor rails, web splice for telpher beam, rail splice and rail stops at each end.

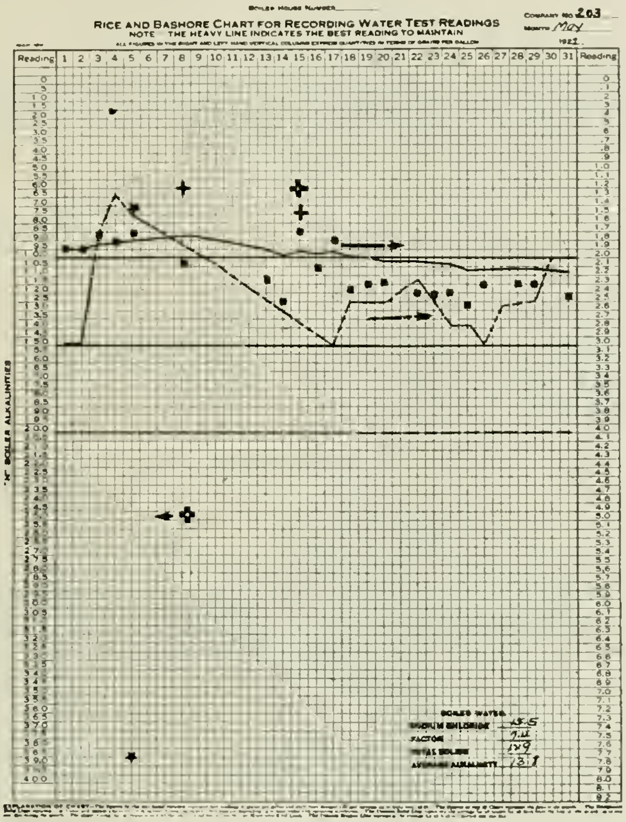


FIG. 6—BOILER FEED WATER TREATMENT CHART

EXPLANATION OF CHART

The figures in the lefthand column represent test readings in grains per gallon.

Small square—Represents the average alkalinity reading for all steaming boilers reported any one day.

Uneven solid line—Represents the average of alkalinity tests for all boilers for all days from the first of the month up to the last day this average is recorded.

Uneven broken line—Represents the average chloride reading of all steaming boilers reported any one day.

Solid cross—Represents the results of our tests for soda concentrations in samples received from the plant.

Broken cross—Represents the results of our tests for chloride concentrations in samples received from the plant.

Star—Represents the day on which a change in treatment was advised by us.

Circle—Represents the day on which the treatment advised was made effective.

Arrow—When placed to the side of a mark points toward the direction on the chart from which the reading is to be taken for all marks of the same kind. Example: One arrow to the right side of a solid cross indicates that the reading for this cross and for all other solid crosses on the chart are to be taken from the right side.

The straight solid line represents the minimum desired alkalinity to be carried.

The straight broken line represents the maximum desired chloride reading to be carried.

All curves shown on the chart as uneven solid lines, broken lines or small squares are plotted on the intersection of the vertical line representing the date on which each test of its kind was reported as being made, and the horizontal line representing the readings.

The solid and broken crosses are placed on the intersection of the horizontal line representing the test readings, and vertical line representing the date the sample was taken, and not the date on which the tests of the samples shipped are made by us.

crusher house 19x11 ft. elevated 20 ft. above yard level.

Coal is received by railroad and is dumped direct from cars to the receiving hopper shown in Fig. 3, from which point it is handled by the Sprague G. B. 7 grab bucket mono-rail crane.

Providing "slack" be received, it is taken direct from receiving hopper to the coal bunker in the boiler house, but if run of mine coal be received, it is lifted by the grab bucket to the 11x13 ft. bin and fed to the crusher by the reciprocating steel plate feeder and from the crusher the coal runs by gravity over the screen and finally comes to rest in either the fine coal or coarse coal hopper, locations of which are shown on Fig. 3, the fine coal being handled from here to the coal bunkers by the grab bucket crane.

Suitable spouts lead from the rack and pinion type gates (controlled from boiler house floor) on the bottom of the coal bunker to the stoker hoppers.

The stokers are Type AA-6 Taylor stokers of 5-retort, 17-tuyere size, built by the American Engineering Company. The three stokers, 15 retorts and the fan are driven by a Troy engine; this fan is of the paddle wheel, three-fourths housed type and is of such size as to operate four stokers at maximum capacity. Two vertical engines, either of which may be direct connected to the fan, are provided; each engine, however, is of sufficient size to operate the fan at maximum capacity and in addition drive four stokers. It is not uncommon to call upon these stokers to burn sufficient coal to develop 225 per cent to 250 per cent of normal boiler rating.

This stoker consists of the following assembled parts:

1. Sloping passages, called retorts, by which coal enters from the hoppers.

2. A series of cast iron tuyere boxes, through which air is forced by a fan, and which are covered by perforated cast iron tuyeres, through which the air enters the fuel bed.

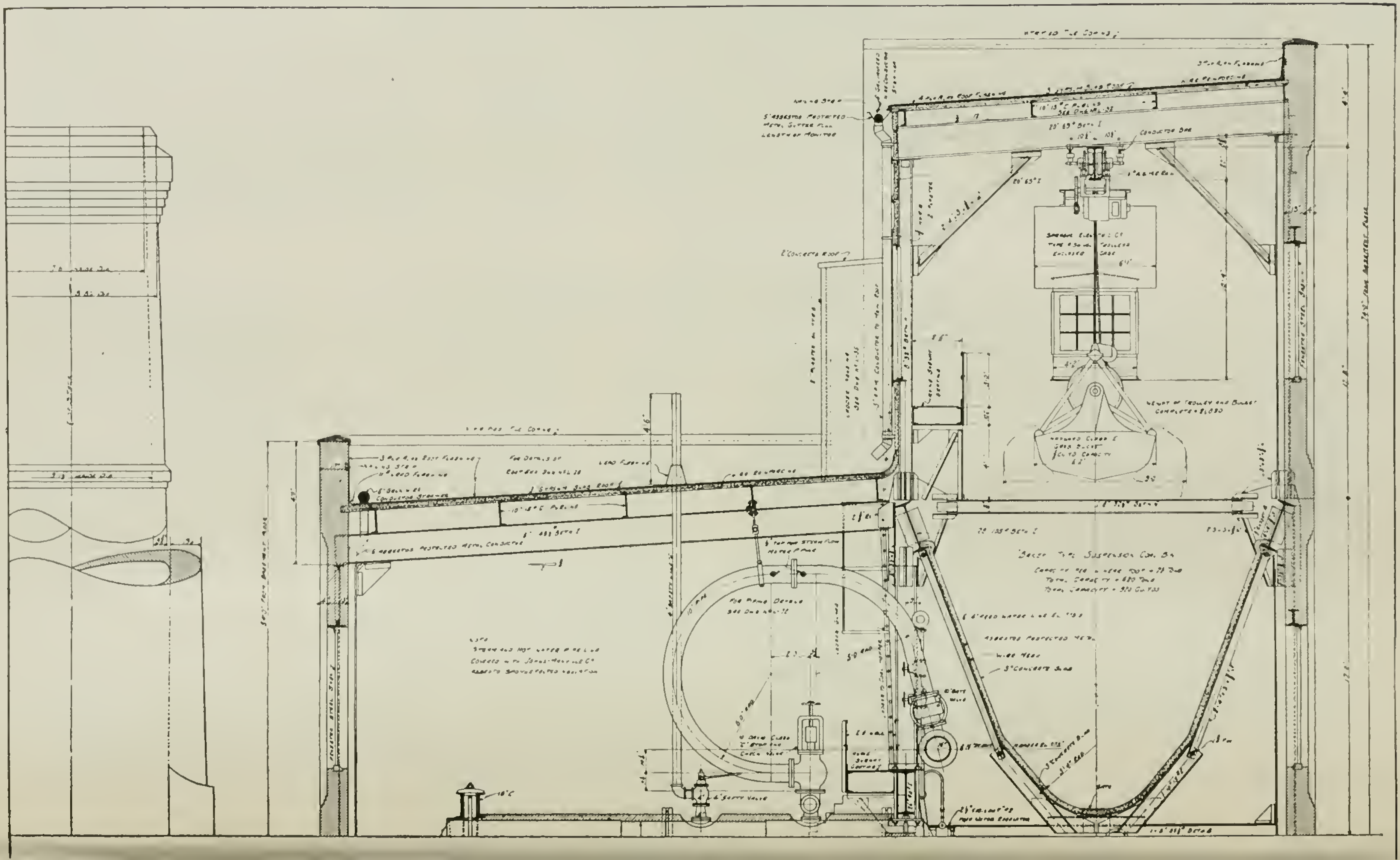
3. Slowly reciprocating rams, driven at variable speed by worm gears from a sprocket shaft. Each retort is served by one feeding ram and a distributing ram. As the coal drops behind them it is pushed upward and backward, working to the surface and eventually past the extension grate to the dump plate, and

4. A dump plate on which hot refuse accumulates and which is dumped every 3 to 6 hours, depending on the rate of working.

The rams are driven by sprockets and worm gearing from a drive shaft below the floor. The distributing ram is operated through a lever from the feeding ram; its stroke is graduated by the lever and may be further adjusted by spacing washers. An extension of this lever imparts a slight movement to the extension grate to prevent clinkers from adhering.

Power is derived from a steam engine; the stokers and fan are run at proportional speeds, according to the load demand.

The first effect of the feeding ram is to push much of the fuel upward. This accounts for the heavy fuel bed—from 2 to 3 ft. thick—which is carried. The green fuel works slowly to the surface, having ample time to distil, and the escaping gases, rising with air from the tuyeres through the incandescent coke above, are thoroughly mixed and burn with an intense, relatively short flame.


5" Asbestos Protected Metal Gutter Full Length of Monitor
Conductor Bar
6'4"
4'2"
Asbestos Protected Metal
Wire Mesh
3" Concrete Slab

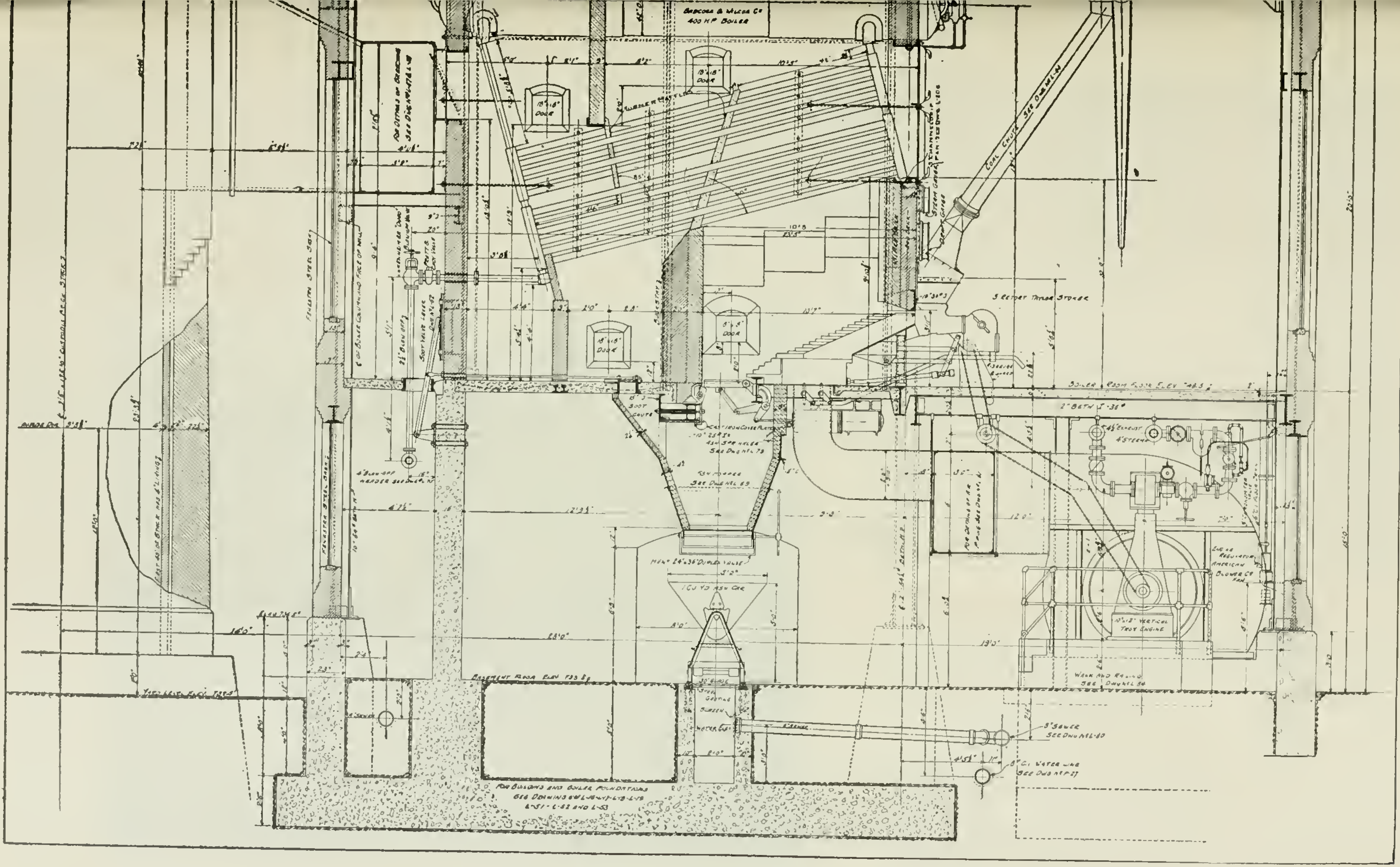


FIG. 7—CROSS SECTION THROUGH BOILER HOUSE

This drawing virtually tells the entire story of the steam generating plant in question. It is to be noted that the boilers are set 15 ft. above the ground line. This unusual height makes possible the desirable location of the ash hopper, of the fan and engines for driving same and for the air ducts. Ashes are very readily removed by means of this arrangement. Attention is also directed to the unusual height of the boiler setting. The front head of the boiler is 10 ft. above the floor line. The arrangement of the stoker and dump plate is clearly shown.

The burning fuel is gradually worked backward and downward, being pushed by fresh fuel, and when it finally reaches the dump plate practically nothing but hot ash and clinker remains.

This type of stoker is equipped with power dump which consists essentially of a steam cylinder located underneath the stoker, together with suitable mechanism connecting it to a dump plate of sufficient size and rigidity.

The dump plate is hinged and is supported at its free edge by a series of pawls set directly into the bridgewall, this to prevent sagging under load. By rocking these pawls, which are rounded so they do not lift the dump plate before releasing it, the dump plate is allowed to drop, and if the fuel contains little or no clinker, nothing else is required, but if the fuel contains clinker, as most soft coals do, part of this clinker forms on the dump plate and lower grate, and part is carried on to the face of the bridgewall where it tends to "hang" when the ashes are dumped; the power dump, however, acts as both hammer and scraper when raised above its normal position. After the ashes have been dumped, steam is admitted to the cylinder, and the slag crust on the bridgewall is scraped off, at one blow ordinarily, and the result is a clean fire, and no clinker building up on the bridgewall.

By referring to Fig. 7 we see the arrangement provided for ash disposal. As the ashes are dumped they fall directly into the ash hopper, bottom of which is closed by the 24x36 in. Hunt duplex ash valves, and as the occasion requires, the soot valve is opened from the rear of the boiler and the accumulated soot falls into the ash hopper through the soot chute.

After dumping, the operator opens a Haas automatic flush valve and a predetermined quantity of water is fed through the ash sprinkler, as shown on Fig. 7, quenching same, after which this ash is deposited in the ash car by opening the "Hunt valves," and then it is taken to the 20x20 ft. ash hoppers, shown on Fig. 3, and dumped.

Final disposal of ash is made by the Sprague grab bucket mono-rail crane, which handles the coal also, loading empty cars, which are spotted under the mono-rail on the coal track from the 20x20 ft. ash hopper.

Boilers.

Two 400-hp. Babcock & Wilcox horizontal water tube boilers, sloping head, double deck, 18 tubes across, 6 rows in lower deck and 5 rows in upper deck, making a total of 198 4-in. tubes 18 ft. long and two 42-in. drums 23 ft. 6 in. long; and one 400-hp. Babcock & Wilcox horizontal water tube boiler, vertical head, single deck, 21 tubes across, 9 rows high, making a total of 189 4-in. tubes 18 ft. long and three 36-in. drums 20 ft. 4 in. long, make up the steam producing equipment. Sufficient space has been provided, however, to accommodate an additional boiler.

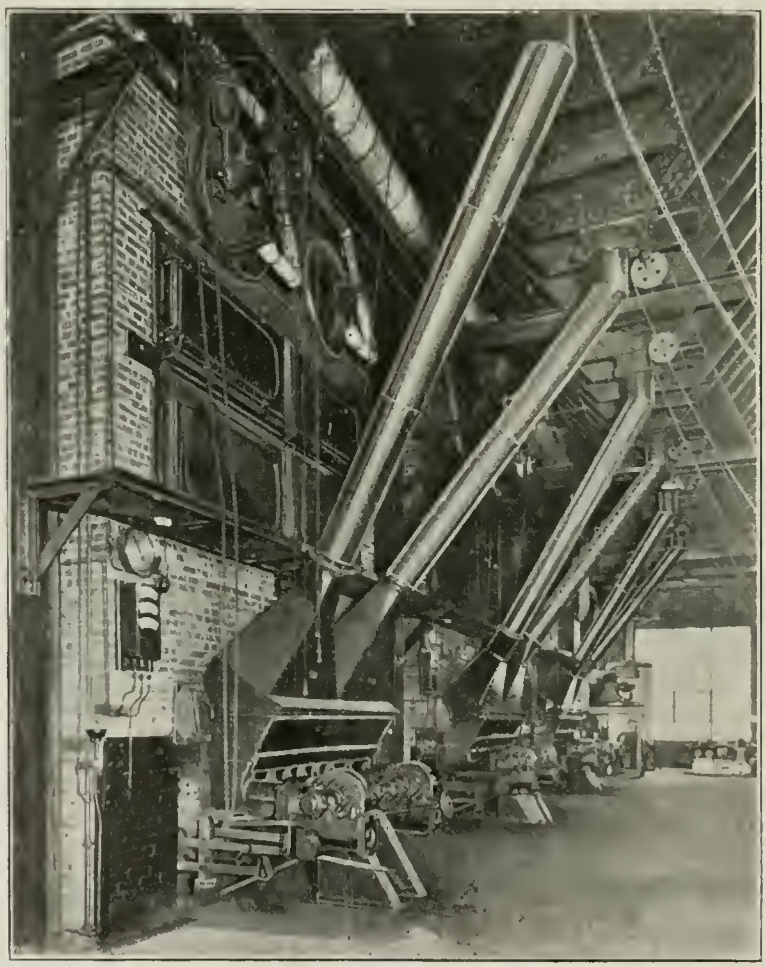


FIG. 8—INTERIOR VIEW OF BOILER HOUSE

A view down the firing aisle showing the plant as it appears at present. Suitable spouts lead from the rack and pinion type gates (controlled from the boiler house floor) on the bottom of the coal bunkers to the stoker hoppers.

One 2,000-hp. National close, outside header type, feed water heater is used. This heater consists of a number of coils of tubing inclosed in a shell or casing; the feed water is pumped through the coils and exhaust steam is admitted to the shell. The feed water is usually raised to within 5 to 10 deg. of the temperature of the steam, resulting in a satisfactory saving of fuel. By referring to drawing, Fig. 3, it will be noticed that provision has been made for a second heater.

Feed Water Pumps.

The feed water pumps are two in number and are both Wilson-Snyder turbine driven centrifugal pumping units, consisting of a 3-in. two-stage, single suction, horizontal type Wilson-Snyder centrifugal pump, direct connected by means of flexible couplings to a 31.6-hp. non-condensing Terry steam turbine. Each pump has a capacity of 130 gallons per min., operating against 150 lbs. boiler pressure and pumping water at 210 deg. F. with 7 ft. static water pressure on the suction. Turbines are fitted with Foster constant excess pressure governors. The pump and turbine are mounted on a heavy cast iron bed plate, making a complete unit.

Brick Chimney.

The forced draft fan, producing a draft of from 1 to 5 in. of water, relieves the chimney of most of its duty, but an Alphons Custodis perforated radial brick chimney 175 ft. high and 7 ft. 6 in. inside diameter at top has been provided.

Feed Water Treatment.

The feed water for our boilers is taken direct from the Allegheny River. This stream drains from an extensive watershed and is subject to contamination with waters from mines, manufacturing plants, and sewerage from various towns along its course. It, therefore, varies considerably in its contained impurities. This is especially true after heavy rains. The tabulated analyses, given below, show just how changeable this river can be, these two analyses having been taken during different periods:

Turbidity	27.0	2.0
Suspended matter	53.0	2.4
Iron	1.5	.2
Silica	3.8	6.4
Calcium	7.4	26.0
Magnesium	1.6	6.0
Sodium and potassium	5.4	21.0
Bi-carbonate radical	24.0	71.0
Sulphate radical	12.0	30.0
Chlorine	6.0	32.0

Between the two analyses given above there is a difference in the principal scale forming constituents of 196 per cent in the carbonates and 150 per cent in sulphates.

Regardless of these changing qualities of the water from the river, our boilers are free from scale and corrosion. This is due to the scientific manner in which the chemical treatment of feed water is controlled, for which purpose we employ the services of Cyrus Wm. Rice & Company, Water Purification Engineers.

This control is affected through a co-operation between these engineers and our boiler room forces, by which the latter, each day, make and forward to the engineers the results of two simple tests of samples of water taken from the steaming boilers.

By this means we are advised just when a treatment is necessary. The service also insures us of the internal cleanliness of the boiler when steaming.

The chemicals required in treating the boiler feed water are dissolved within a chemical dosing tank of 250 gallons capacity located slightly above floor level in the basement of the boiler house. A small pump draws the soda solution from this tank and delivers same either into the main feed water discharge between the closed heater and boilers, or into each boiler. The object of the separate connections is to introduce an additional quantity of chemicals into any one steaming unit where the daily test readings indicate the necessity for such additional treatment. After a water is dosed with the chemicals, it is very important that representative samples be obtained of the boiler feed water before and after the treatment is added. For such purposes we collect one sample each of the raw and treated waters daily and one sample of water from each steaming boiler. All samples of raw and treated water are drawn uniformly over a 24-hour period into separate wooden containers located in the basement of the boiler house. At about the same time each day a 4-ounce sample of each of the above waters is taken from these barrels and placed into separate glass containers for collecting the weekly samples we forward the engineers for their laboratory analysis. This is done as a check on the boiler room force and on the effectiveness of the treatment within the boilers.

The sample of boiler water is taken after one of the regular daily blow downs from a ½-in. drip connection located on the blow-down pipe of the boiler. These blow-down samples are tested by one of our boiler men and results of the test reported direct by him to the engineers as above mentioned.

At the end of each month we receive a complete report showing the results of each test that was made by our boiler room forces and by the engineers. A copy of the report we receive is given herewith. (See Fig. 6.) Through such a record we can at any time check the work of our own men and that of the engineers we hire for this purpose.

NATIONAL SAFETY COUNCIL PASSES RESOLUTIONS

Arthur H. Young, of the International Harvester Company, president of the council, in his annual address, August 28, at the Cass Technical High School, Detroit, made special reference to the comprehensive public safety program of the council and announced that a large sum of money had been made available by a group of insurance companies to aid the council in its campaign against automobile accidents. He placed particular emphasis on the value of its practical cooperation in as being a significant era in the progress of general accident prevention. He paid a tribute to the railroads in the Careful Crossing Campaign and to the hundreds of local safety organizations doing safety work in many cities through out the country. He prophesied that in time all preventable accidents will be prevented and that the people of the United States will take as jealous and watchful care of their lives and limbs as they now do of their dollars earned, saved and invested through fixed and ingrained habits of safety.

The congress adopted a resolution endorsing a safety platform for 1923 as follows:

> Whereas, the 80,000 accidental deaths and millions of injuries occurring each year on our streets, in our industries, in homes and elsewhere are a blot on American civilization and the cause of untold suffering and sorrow, and
>
> Whereas, the direct economic cost of industrial accidents alone exceeds one billion dollars annually, and
>
> Whereas, experience has demonstrated that at least 75 per cent of industrial accidents are preventable and that approximately an equal reduction is possible as regards public accidents, therefore be it
>
> Resolved: That the National Safety Council in its Eleventh Annual Congress in Detroit assembled advocates:
>
> 1. The safeguarding of all dangerous machinery and places according to standard methods of proved value;
>
> 2. The development of industrial equipment and processes along lines of inherent safety for the double purpose of eliminating accident hazards and increasing production efficiency;
>
> 3. The education of all workmen and their supervisors in safe methods and habits of work;
>
> 4. The training in safety of all school children, as well as students in colleges and universities, both for their own protection and as an object lesson in good citizneship;
>
> 5. The adoption and strict enforcement of uniform, practicable laws and ordinances for the safeguarding of vehicular traffic and the protection of the multitude of law abiding drivers and pedestrians against the thoughtlessness and recklessness of the few; and
>
> 6. The mobilization of all community forces through state and city safety councils for securing those ends through the overwhelming force of enlightened public opinion.

Iron and Steel Electrical Engineers Convention

The Sixteenth Annual Convention of This Society Held in the Cleveland Public Hall, September 11th to the 15th, Surpassed All Previous Meetings—Twenty-three Hundred Registered.

TWENTY-THREE hundred iron and steel electrical engineers and their friends registered for the sixteenth annual convention of the Iron and Steel Electrical Engineers held in the Public Hall, Cleveland, September 11 to 15. They were rewarded in many ways. The size and attractiveness of the exhibits in which 85 exhibitors showed their product, far surpassed any previous iron and steel electrical exposition. The technical papers were the most complete ever presented before this society. The convention hall, which was erected by the city of Cleveland at the expense of $6,500,000, was particularly well suited for the convention, as it provided ample space in every way.

The annual banquet, held at the Statler Hotel, Thursday evening, was attended by approximately 500 engineers. The program for the banquet included such interesting speakers as Charles P. Steinmetz, chief consulting enginer of the General Electric Company; the retiring president, W. S. Hall, electrical engineer, Illinois Steel Company, South Chicago; J. S. Unger, manager of the Research Department, Carnegie Steel Company, and C. L. Collens, president, Reliance Manufacturing Company, Cleveland. H. P. Bope, formerly general sales manager of the Carnegie Steel Company, was toastmaster.

The Cleveland Section entertained the visitors Tuesday evening with a dance and an organ recital at the Public Hall. An interesting lecture on the "Science of Numbers" was given by E. Kieft, engineer of tests at the Gary plant of the Illinois Steel Company. At the business meeting Monday morning, Foreman R. B. Gerhardt, electrical engineer, Bethlehem Steel Company, Sparrows Point, Md., was elected president for the ensuing year. Other officers elected were as follows: First vice-president, L. F. Galbraith, electrical engineer, West Penn Steel Company, Brackenridge, Pa.; second vice-president, R. L. Shoemaker, superintendent of maintenance, American Rolling Mill Company, Middletown, Ohio; directors, A. C. Cummins, electrical superintendent, Carnegie Steel Company, Duquesne, Pa.; E. H. Wentz, electrical superintendent, National Tube Company, Lorain, Ohio; B. G. Beek, electrical engineer, American Sheet & Tin Plate Company, Gary, Ind.; George Schaeffer, electrical superintendent, Carpenter Steel Company, Reading, Pa., and A. L. Freret, assistant chief electrical engineer, Tennessee Coal, Iron and Railroad Company, Birmingham, Ala.; treasurer, John Farrington, electrical superintendent, LaBelle Iron Works, Steubenville, Ohio; secretary, John F. Kelly, Pittsburgh.

Dr. Steinmetz, during the course of his paper, said in part as follows:

"There are three ways of supplying power to an industry.

"The isolated plant without connection with any electric power system. The advantages and disadvantages of this arrangement have been discussed in the preceding. Where considerable energy is available as by-product of the industry, the cost of power from a local isolated plant may figure lower than power can possibly be bought from the central station. This, however, may have little meaning, as it depends on the value assumed for the by-product energy used as fuel by the local plant. If the by-product energy is not sufficient for the total power demands of the industry, additional fuel has to be used; where there is more by-product energy than required to produce the power, the surplus may be wasted, or an attempt made to find some other use for it. Or it may also be converted into electric power and some of the electric power sold. Or some industrial uses for the surplus electric power may be developed, such as electric smelting or refining. The latter probably is the most economical arrangement.

Or the electric power required by the industry may all be bought from an electric power system, and no local plant operated. This is most convenient, but depends on the rates which can be secured from the electric power company. In general, the power would be bought in bulk under a rate based on maximum demand and on power factor. It would therefore be economically desirable to arrange the industrial operation so as to have as nearly as uniform power consumption as possible, without large peaks of power consumption, so as to have the maximum demand exceed the average demand as little as possible and thereby to get the best rates. For power, synchronous motors should be used as far as possible, and operated over-excited so as to compensate for the lagging currents of induction motors. Power factor corrective devices, such as synchrononous condensers, may be installed in the substation. The substation with its transforming, regulating, power factor controlling devices, etc., may be owned and operated by the power company, or by the industrial corporation, or it may be owned by the one and operated by the other. The power may be metered on the primary side of the substation, or on the secondary side. The general economic principle, I believe, should be that everything pertaining to power generation, transmission, transformation, control, etc., should be operated and preferably also owned by the power supply company, as being a legitimate part of the electric power industry; while everything pertaining to the application of the power to the specific industry served by the substation should be operated by the industrial corporation. The specific arrangement which can be made will however to some extent depend on the financial strength, on the progressiveness of the management and the far sightedness of the engineering staff of the two companies.

If there is considerable by-product energy, some arrangement should be made to fully utilize this available energy. If the by-product energy is wasted entirely by not being used, or wasted intrinsically by being put to an inferior use, for heating only, instead of first taking out the available mechanical power, then the arrangement is uneconomical, even if financially the central station power supply should figure out an advantage.

"Where considerable by-product energy is available, and where central station power supply is possible from an electric power system, central station service may be combined with the operation of a local station.

"A part of the plant may be operated from the local station, another part by the central station power, leaving both electrically separated, but with arrangements whereby feeders may be connected over from the one service to the other. Or part of the time the plant may be operated from the local station alone, and central station power used only when the load exceeds the capacity of the local station. Or the connection to the central station may be entirely or essentially that of standby or emergency service, and normally the local plant supply all the power.

"Or the local station and the central station both may feed into the same set of local busbars, from which the power supply of the plant is taken. Various possibilities then exist in the arrangement of the load distribution between local and central stations.

"Power may be bought from the central station at unity power factor constant load, that is, unity load factor, and the fluctuation of load and the wattless current supplied by the local station. This would give the lowest cost (except off peak power) of the central station power, and therefore should give the best rates of power, those of continuous non-inductive load. It necessarily makes the local station operate less efficiently, and, where operated by by-product power requires sufficient storage facilities for such by-product power, to supply it at the rate demanded by the load fluctuations. Also, the generator armature and the generator fields may not be able to carry the excess current required in both to supply all the lagging currents of the system. This would have to be looked into.

"Or, instead of carrying all the load fluctuation and all the wattless currents by the local station, investigation may show it more economical to throw some load fluctuation and some wattless currents to the central station supply, when the gain in efficiency of operation of the local station, given thereto, is greater than the increase of cost of central station power. For instance, the central station rate may be the same for power factors from 90 per cent to unity, and then it would be of disadvantage to carry more wattless currents by the local station, than necessary to keep the power factor of the central station supply above 90 per cent.

"Where a daily or annual peak are a factor in the cost of central station power generation, and off peak power therefore of lower cost than continuous power, lower rates may be secured if the plant operation can be organized so as to disconnect the central station supply for a few hours during the day, and operating on local power only. Or a two-rate metering may be arranged, that is, a lower meter rate during the off peak period. This would allow the use of central station power during peak load, if so required by the industry, but put a premium on avoiding it and securing the lower rate of the off peak power.

"Another way of operation would be, to carry constant load on the local station, and take the fluncuations by the central station service. In this case a less favorable price of central station power would result, but the local station would work at best economy. With by-product energy, the local station may then be operated at such output as to consume the byproduct energy at the rate at which it is produced, and eliminate the need of storage.

"The most economical arrangement between local station and central station power supply to a large extent depends on local conditions of power demand and supply, on the possibility of modifying the power demand to get more favorable conditions, and is deeply involved in the matter of rate making. While the economic principle of rate making is to arrange the price in proportion to the cost of power, as depending on quantity and quality (such as load factor and power factor, peak and off peak), the actual rates may not quite represent this, and the lowest rate may not always be the most economical."

GERMAN TECHNICAL BOOK REVIEW

By HUBERT HERMANNS

L. Litinsky, Wet-Cooling of Coke and Utilization of the Coke Heat. (Trockne Kokskuhlung mit Ausnutzung der Koksglut) 52 pages, 18 fig., 7 tables. Published 1922 by Otto Spamer, Leipzig. The different methods of utilizing coke heat are described, especially the method of using amorphous gases which utilizes the coke heat for generating steam in an economical way.

F. W. Hinrichsen and S. Taczak, The Chemistry of the Coal (Kohlenchemie) 3rd Edition, 523 pages. Published by W. Engelmann, Leipzig. The origin and the artificial production of coal; properties, distinction and classification of the natural coal according to its nature, microstructure, mechanical qualities and behaviour in heating; decomposition and self-ignition of coal; chemical and calorimetric testing of coal; the most economical utilization of fuels.

Edmund Schlosser. Soldering and Welding (Loeten und Schweissen). A handbook for the practice; 257 pages, 81 fig., fifth edition. Published 1922 by A. Hartlebens Verlag, Leipzig and Vienna. Solders and soldering devices; the electric and autogeneous welding.

Max Le Blanc, Compendium of the Electro-Chemistry. (Lehrbuch der Elektro-Chemie); ninth and tenth edition; 370 pages, 32 fig., published 1922 by Oskar Leiner, Leipzig. Development of the Electro-Chemistry during the 19th century; theory of the electrolytic dissociation of Arrhenius; determination of the ions; conductivity of electrolyts; electric endosmose; electromotive forces; electrolyse and polarization.

A. Schelest, The Specific Heat of the Gases and Vapors (Die spezifische Warme der Gase und Dampfe) 12 fig. Published 1922 by Franz Deuticke, Leipzig.

Judging the Combustion of Gaseous Fuels From Gas Analyses

By A. G. WITTING*

WE combustion engineers have a field of action of great importance. The consumption of fuel in a steel plant is enormous and the amount of potential heat value, carried by this fuel, that is not fully utilized should to us at all times seem to be too great. We should indeed be remiss in our endeavor if we did not consider the fuel practice obtained, even though relatively satisfactory, as standing in need of improvement; there is no doubt that even what is well done could be done a little better. In a plant like ours where up to 150 million cu. ft. of coke oven gas and between 800 and 900 million cu. ft. of blast furnace gas are daily produced and in addition over 2000 tons of coal are converted into producer gas the unavoidable losses represent a great money value; and in spite of the constant and conscientious efforts of the management to minimize it, the waste mounts high when translated into lbs. of coal equivalents. We are, all of us, trying our hardest to combat this condition, even if our efforts often show very discouraging results. But while it is only the practical results that count and theorizing often leads us to try to find excuses instead of remedies, nevertheless it is only through the correct application of theories (which themselves should be based entirely on practical results), that practical results are obtained. They are evolved from experience, but so many factors play in that the deductions drawn from this experience sometimes may stand in need of correction. It is, as I understand it, one of the objects of the Combustion Section of the Association of Iron and Steel Electrical Engineers to have its members bring such questions under discussion for the purpose of getting a better understanding of some of the phenomena that rule combustion.

The prime object of our work is to cut down fuel consumption, to obtain perfect combustion with a minimum surplus of air. In our pursuit of this goal we should, of course, direct our efforts to find improved methods and means for producing such a combustion, and there is a large room for improvement in the design of burners, furnaces, etc. But we should never lose sight of the fact that these are only tools, and that the handling of the same in the most efficient way is of greater importance, that the operator must know how to regulate his fuel and air supply, his furnace, burner or producer in as effective manner as possible. But the operator will not be able to do this unless he is familiar with the true theories governing his special problem of combustion. Whether he knows them or not, he will, if he is conscientious, get satisfactory results as long as everything is running normally, but if ignorant of these theories he will not be able to meet an emergency. Proceeding from wrong conclusions, he is apt to apply the wrong remedy. He is like a man groping his way in a fog; as long as he travels his beaten path in familiar surroundings he will get on; but place an obstacle in his way that forces him out of his path and he is lost. It is up to us combustion engineers to spread the light that will penetrate the fog, but to do this we must know ourselves where the light is and how to handle it.

It might then be said that it is not so much normal as abnormal combustion conditions which should be the object of our studies. But the passage from a normal to an abnormal condition is gradual, and consequently not easy to detect by casual observation. We have nowadays at our disposition a great variety of measuring and recording instruments which are of a great help and which have done much to reduce fuel waste because they can tell us more accurately, than the eye, how everything is. They are as important to us as the barometer, the compass and the sextant to the skipper who, without them, would be lost.

But even though these instruments can tell us and the operator when a condition becomes abnormal, there are instances when we can not directly from them detect what caused this condition, which is the only thing that really counts. It becomes necessary for us to examine closer into the process of combustion, and the means at our disposition for such an examination is the old standby, the gas analysis.

It is my intention with this paper to discuss the significance of gas analyses or, more exactly, to advocate the better utilization of one kind of gas analysis, the waste gas analysis, and warn against the indiscriminate use of another kind, the producer gas analysis. In connection with this latter question I will also present some viewpoints on the important but often side-tracked function held by those constituents of the producer gas which, being condensable, escape our analyses, and lay before you the result of some investigations into the nature of these tarry vapors.

Waste Gas Analysis.

For metallurgical purposes the gaseous fuels are used: blast furnace gas, coke oven gas and producer gas. Their heat value and the efficiency of their combustion is judged from analyses and from the heat balance indicated by them; heat balance meaning the heat delivered to and usefully absorbed by the place of combustion, or the difference between the heat developed in the combustion plus the sensible heat in the gas and the air (if preheated) minus the sensible heat carried away by the waste gases.

A complete heat balance involves so many factors, that it to a large extent depends on guess work or arbitrary assumptions—its value is consequently, to say the least, questionable. To make up such a heat balance, for example, for a hot blast stove gas burner,

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[*] Assistant Chief Engineer, Illinois Steel Company, Gary, Ind.

Abstract of paper presented at convention of Iron and Steel Electrical Engineers. Complete papers and discussions can be secured from J. F. Kelly, Empire Bldg., Pittsburgh, Pa it is necessary to obtain not less than nineteen items of information, each requiring a series of observations taken during the same time. I am tempted to say that such a feat has never been really accomplished. But on the other hand, the efficiency of the combusition, itself, the more or less correct manner in which the fuel and its air supply is handled by the operator, can be judged exactly from an analysis of the gas and an analysis of the products of combustion, provided that both samples are taken simultaneously, not the one immediately after the other.

It is clear, that the highest efficiency is developed when all the combustibles in the gas and all the oxygen in the air are consumed, leaving in the waste gases nothing but CO_2, N_2 and H_2O. This means a 100 per cent reaction and is in practical operation not attainable. The fuel is burnt either with an oxidizing flame, with a surplus of air, indicated by the presence of oxygen in the waste gas analysis, or with a reducing flame, the air supply being below requirements so that combustibles are carried away with the waste gases and appear in their analysis. It also happens that both oxygen and combustible gases at the same time occur in the waste gases. In the latter two cases a direct comparison between the two analyses is not possible, the composition of the waste gases can not be calculated directly from the gas analysis. Under these conditions it has been customary to figure the waste gases produced on the assumption that all the carbon in the original gas is found in the waste gas, the volume of the latter comparing with the volume of the former as the CO_2 that would have been produced by complete combustion compares to the CO_2 in the waste gas analysis plus the CO_2 that would have been produced by the unburnt combustibles.

Now, very often in metallurgical operation the waste gases contain CO_2 which is not derived from the fuel. When this occurs there exists, at least to the writer's knowledge, no published method by which the combustion process can be calculated. It is the purpose of this paper to set forth a series of simple formulas which will assist in solving such problems.

Complete Combustion.

For the numerical examples introduced in the paper or in the appendices attached to it I have been using the standard values for chemical reactions. As a help to anybody who may want to check my calculations I have collected these values in a table which appears in Appendix No. 1.

I have assumed that the air by volume contains 21 per cent oxygen and 79 per cent nitrogen, and that accordingly one cubic foot of oxygen in the air is associated with 3.762 cubic feet of nitrogen, making 4.762 cubic feet of air. The high, or gross heat values are used for blast furnace gas and coke oven gas, because corroborative calorimetrical tests are generally made with these gases. For producer gas the lower or net values are mostly used, as this gas is not tested by calorimeter. This is, of course, not a rule laid down, only an explanation of my method of calculation.

To determine the efficiency of a burner or a furnace operation we have obtained our two gas samples, the waste gas sample being collected at a point where any danger from outside influence, air leakage for example, is as far as possible eliminated. If the analysis of the waste gas does not show any combustibles present, the chances are that oxygen is found. The question then naturally is: how much surplus air has been admitted? It will be necessary first to calculate the requirements and results of a theoretically perfect combustion. Having thus obtained the volume of the products of combustion, neglecting the condensible moisture, the amount of air present in the waste gases, as indicated by a certain percentage of oxygen and the total volume of waste gases, is obtained by means of the following formulas:

$$(1)\quad A = \frac{Pa}{21\text{-}a} : W = \frac{21P}{21\text{-}a}$$

When A = amount of surplus air.
P = products of complete combustion (minus moisture).
W = total amount of waste gas = A ÷ P.
a = percentage of oxygen in waste gas.

Appendix No. 2 gives an example of such a calculation when the fuel was blast furnace gas. 100 cubic feet of this gas required 71.43 cu. ft. of air and gave 153.43 cu. ft. of waste gases (not counting the H_2O). The waste gas analysis showed 1.8 per cent oxygen, which meant that the waste gases contained 14.38 cu. ft. surplus air corresponding to a surplus of 20 per cent that the total amount of waste gases produced from 100 cu. ft. of gas was 167.81 cu. ft. to which, of course, has to be added the amount of water vapor calculated from the gas analysis plus the moisture contained in 100 cu. ft. of gas and 85.81 cu. ft. of air.

Incomplete Combustion.

The usual method of figuring the volume of the waste gases when the combustion has been incomplete, from the carbon contents does not need any demonstration here because this method, as stated in the introduction, can not be employed if any carbon dioxide has been added to the waste gases from any other source than the fuel gas itself, as usually is the case in an open hearth funrace. Besides, it offers no advantages over the one I am going to submit and which is based on the air present, whether used for combustion or left as a surplus in the waste gases. The formula may appear unwieldly and downright formidable. But in the by far greater majority of cases most of the factors in the formula will be eliminated as not appearing in the analysis.

Composition of Fuel Gas		Composition of Waste Gas		
	Analysis		Analysis	Volume
CO_2	a%	CO_2	h%	hw
C_2H_4	b%	C_2H_4	j%	jw
CO	c%	CO	k%	kw
H_2	d%	H_2	l%	lw
CH_4	e%	CH_4	m%	mw
C_6H_6	f%	C_6H_6	n%	nw
N_2	g%	N_2	p%	pw
O_2	o%	O_2	q%	qw
H_2S	s%			
	100%		100%	100w

$$(2)\quad w = \frac{y + v - o}{x + z - q} \quad \text{if } x = \frac{21}{79}p;\quad v = \frac{21}{79}g$$

$$y = 3b + \frac{c}{2} + \frac{d}{2} + 2e + 7\tfrac{1}{2}f + 1\tfrac{1}{2}s$$

$$z = 3j + \frac{k}{2} + \frac{l}{2} + 2m + 7\tfrac{1}{2}n$$

After the volume of the waste gases in this manner has been established, other information wanted is obtained by the following equations:

(3) Air present: $Ap = \frac{100\ (pw - g)}{79}$

(4) Surplus air. $As = \frac{100\ q\ w}{21}$

(5) Air needed for complete combustion—

$$Ac = \frac{100\ (y - o)}{21}$$

(6) Useful air:

$$Au = Ap - As = \frac{100\ (y - zw - o)}{21}$$

(7) Co_2 addition $= w\ (h + 2j + k + m + 6n) - (a + 2b + c + e + 6f)$

In Appendix No. 3 the derivation of the formulas is explained and the application of the same is illustrated by a couple of examples with check-ups which prove the correctness of the formulas.

As it is not necessary, when using this method for calculating the waste gases, to figure the results of a theoretical combustion, but it always is required to know the amount of water vapor produced, the same will be obtained by means of the following formula:

(8) $H_2O = (2b + d + 2e + 3f + 2s) - w\ (2j + l + 2m + 3n)$

With the assistance of these formulas any waste gas analysis, no matter what it contains or in what manner the CO_2 has been produced, can be translated into cubic feet, providing an analysis of the fuel gas has been taken simultaneously with the waste gas analysis. It is, consequently, no longer necessary to arrive to your deductions by guessing. You will know positively how great a percentage of the combustibles in the gas has passed unconsumed through the furnace or how great the surplus of air has been or what percentage of the CO_2 has been added to the gases from the material in the furnace. In this way it will also serve as a check on the analysis itself.

Producer Gas Analysis.

As just stated, it is at all times necessary to give proper attention to the amount of condensible matter in the gases which the analyses unfortunately neglect. This necessity becomes still more important when the question is of producer gas which always carries in addition to water vapor a certain amount of so-called tarry vapors, products of the distillation of the volatile matter of the coal, which can not be analytically determined. Writers on the subject generally satisfy themselves with calling attention to their existence and then forget them, continuing the discussion as if producer gas was non-condensable like blast furnace gas or coke oven gas.

It is the object of the following part of the paper to make clear how erroneous the conclusions might be which are drawn under the assumption that the ordinary producer gas analysis shows up a hundred per cent of the gas generated from the coal in the producers.

The writer has given this phase of the fuel problem considerable study and succeeded to construct from analyses the probable composition of the volatile matter in Indiana Coal from the Clinton district. It would require too much space, and be partly outside the subject, to repeat in detail the methods employed; and I will, therefore, content myself with saying that a double cross-checking of the result obtained, verified the same remarkably well.

The laboratory analysis of the coal in question gives the following composition:

		Ultimate Analysis	
Volatile matter	35.51%	Total carbon	67.91%
Fixed carbon	48.28	Hydrogen	4.57%
Ash	9.41		
Moisture	6.80		
	100.00%		

The constituents of the volatile matter determined by a series of analyses and with the assistance of analogies from analyses of similar coals made by the Bureau of Mines were as follows:

Condensable hydro-carbons	10.052%
Permanent gases	18.262%
Neutral condensates, H_2O and H_3N	7.196%
	35.510

Our method of taking producer gas samples is to collect them unknown to the gas makers regardless of the conditions of the producers, so as to get as true an average as possible and not—as too often is the case—a series of analyses that look very attractive on paper but mean nothing to the one that supervises the operation of the producers.

Selecting, for the purpose of proving my suspicions, with regard to the true value of an analysis, the latest 50 analyses taken as a daily routine work at our open hearth furnaces, I obtained an average composition of the gas produced from this coal of:

CO_2	8.0%
C_2H_4	0.4%
CO	20.3%
H_2	8.1%
CH_4	2.6%

The average low heat value was 118 Btu.

Appendix No. 4 gives more in detail the composition of the coal and the composition of the gas.

The gas is, as everybody knows, produced from the coal partly through direct gasification of the fixed carbon by the blast (a mixture of air and steam) and partly through distillation of the volatile matter. In addition, secondary reactions of varying nature have taken place, stabilizing the hydrocarbons in the volatile matter into gases that are permanent in heat. These processes may be considered either as a series of pyrogenetic reactions, whereby the hydro-carbons, at the high temperature prevailing, are condensed into higher compounds and free carbon, or cracked up into more simple non-condensable compounds and free hydrogen, or else as direct reactions between the hydro-carbons and the distillation products (particularly CO_2 and H_2O and, of course, oxygen if due to a thin fuel bed or channels in the same, the oxygen has not all been absorbed in the gasification zone), forming CO and H_2. A true understanding of these reactions are of highest importance in the correct operation of a producer and they offer a wide field of study which, however, is outside the scope of this paper. I will, therefore, content myself to call the attention to them.

In considering the influence of these secondary reactions on the composition of the gas, we might assume three possibilities:

1. That only the first kind of reactions takes place, viz: that all the tarry vapors enter the gas as stable hydro-carbons.
2. That only the second kind of reactions takes place, viz: that all the tarry vapors are broken up and converted into permanent non-condensable gases, so that the gas analysis represents hundred per cent of the gas produced.
3. That both kinds of reactions occur simultaneously, the preponderance of the one or the other, depending on operating conditions, but with the result that the gas always contains some condensable hydro-carbons and the gas anlaysis consequently does not represent all the gas.

It being generally conceded that the gas receives its luminosity from the hydro-carbons and that this luminosity is of highest importance, at least in open hearth practice, it follows that the quality of the gas is improved to the degree in which the first kind of reactions dominate.

Now, there may exist a difference of opinion on this question, in a paper recently read before the American Society of Mechanical Engineers not only the need of luminosity in gas used at open hearths was questioned, but the author tried to prove that the tarry vapors in the gas had nothing with the luminosity to do. But I take the stand that luminosity is a necessity and that while luminosity might be obtained in other ways, it is imparted to producer gas practically altogether from the hydro-carbons in the gas which dissociate in the flame precipitating solid carbon, which not only when brought to a white glow gives off a dazzling light but being equal to the so-called "perfect black body," possesses greater radiating power than any other solid. The author referred to presents some figures to prove "that the illuminants in the gas are non-essential." Now, against this statement I want to call your attention to the fact that, as everyone unfortunately is fully aware, the waste gases from a fire where coal or a gas produced from coal is the fuel, might issue from the stack as a dense black smoke. This color of the smoke is due to soot or carbon particles dissociated from hydro-carbons in the flame, but for one reason or other cooled below their ignition point. No matter how bad the combustion, it must be assumed that never 100 per cent of the carbon in the gases leaves the combustion chamber unconsumed, that, in other words this soot in the waste gases represents only a fraction, even if it is a large one, of the carbon present in the flame, and there heated to the temperature of the flame. It is claimed that the actual carbon in dense black smoke amounts to 1 per cent of the carbon in the coal and that this carbon under the microscope appears as clusters of small particles about 0.000002 in diameter.

I think everybody will agree that these clusters, or visible smoke particles, will pass through a hundred-mesh sieve, if they are not smaller. It is easy to calculate that under this assumption every cubic foot of waste gas at the top of the stack (temp. = 300 deg. F.) would contain about 5,400 such particles, evenly distributed in the gas. Assuming on the other hand a producer gas of ordinary quality or one with half of its tarry vapors destroyed in gasification (about which more later on) and that one-half of the remaining tarry vapors are lost in the mains and checker chambers, which is an extravagant assumption, then in the combustion of this gas with air in excess creating a temperature of 3,300 deg. F. each actual cubic foot of the gas mixture in the furnace will according to the same method of calculation, contain about 4,400 such carbon particles, pretty near as many as those which in a cold state were able to color the waste gases black. The open hearth furnace chamber would then hold about 15,000,000 incandescent specks of carbon emitting a brilliant white light; and I am sure that it could safely be assumed that they would produce some luminosity. Without a question of doubt, the carbon particles in the gases in the furnace are many times smaller and coagulate to the visible size in which they appear at the top of the stack during the passage through the flues, and consequently it may be assumed that the number of luminous specks in the furnace chamber is too large to be expressed in figures.

Having made this digression to strengthen my statement that the producer gas receives its luminosity from the hydro-carbons, I might take up the argument where I left off and say that it follows that the quality of the gas is improved to the degree in which the tarry vapors in the volatile of the coal are converted into stable hydro-carbons. The question then presents itself: Can the ordinary gas analysis tell us whether the hydro-carbons are more or less preserved in the gas?

I am sure that the majority of combustion engineers will answer: "Yes, the higher Btu. in the gas, the higher is its quality.' This is probably correct in a general way, but I claim that it is not necessarily so, and that very often a gas with a fine looking analysis is defunct in hydro-carbons. In other words, I claim that it is absolutely impossible to tell from the gas analysis whether the hydro-carbons in the tarry vapors have been preserved or destroyed.

To prove this statement I have set forth in Appendix No. 5 a series of detailed calculations based on the analyses of coal and producer gas which I quoted before. You will see from these calculations that the very same analysis can be obtained whether all the hydro-carbons have been destroyed and converted into fixed gas, whether they are all preserved but stabilized or whether part of them are destroyed and part of them preserved. The gas produced from one pound of coal according to the one or the other condition might have identically the same analysis, but its physical properties are decidedly different as the following table will show:

GAS PRODUCED FROM ONE POUND OF COAL

	Cu. Ft. Fixed Gas	Cu. Ft. Tar Vapors	Cu. Ft. Water Vapor	Total Cu. Ft.	Btu. per Cu. Ft.	Total Btu..
Case 1 All tar vapors destroyed ..	66.3	...	9.1	75.4	103.7	7822
Case 2: All tar vapors preserved ..	56.9	0.3	9.3	66.5	127.7	8490
Case 3: 50% tar vapors preserved ..	61.9	0.15	9.2	71.0	114.9	8156

Not only is the total heat value, obtained from one pound of coal, considerably lessened as the tar vapors are cracked up and fixed but, what is very much more important, the actual heat value per cubic foot when the moisture is considered, is in reality not 118 Btu. but might be as high as 127.7 Btu. or as low as 103.7 Btu. And to this you must add the heat transfer capacity, the radiating power of the gas, which, as I hope I have proved, depends entirely on the tarry vapors preserved, or more correctly, on the amount of condensed hydro-carbons contained in the gas.

No doubt, the majority of combustion engineers has some time been puzzled by the apparently anomalous fact that a gas having a good analysis burnt with a thin flame lacking "body" while another furnace had a sharp, quick-working flame, although the gas analyzed lower. The data presented here ought to give a satisfactory explanation to such puzzles and substantiate my claim that the analysis of the gas does not offer any indication of to what degree the tar vapors remain in the gas. It might be possible, although highly improbable, that the gas production has followed the lines of Case No. 1 with all the vapors reduced to fixed gas. Again it might be possible, although just as improbable, that all the tarry vapors, according to Case No. 2, remain as hydro-carbons in the gas. Neither is there anything to warrant the assumption that the gasification takes place exactly according to Case No. 3 on a fifty-fifty basis. It might be 75 per cent or more either way. But as long as any assumption has to be made, this condition might just as well be accepted because, as shown in the following, it offers some simple figures to be used in the calculations, and it is close enough so that the results of the calculations need not be misleading.

The question naturally presents itself: If the quality of the gas chiefly depends on the presence of hydrocarbons and the gas analysis can not tell anything about it and consequently is not a dependable indicator of the quality, what is then the use of a gas analysis? My answer is, that gas analyses are nevertheless very useful, as long as they are used with discrimination. They are, to begin with, indispensable in any calculations concerning combustion. They will, furthermore, give a good relative comparison of the operation of the individual producers in a plant where the producers are of the same type and operate on the same kind of coal. Besides, it is possible by means of gas analyses, if taken in a certain way, to determine the real quality of the gas, viz: whether the majority of the hydro-carbons are destroyed or remain in the volatile.

In a gas producer of the usual design the secondary reactions cracking up the hydro-carbons into fixed gas, are generally caused by CO_2 and H_2O attacking the hydro-carbons forming CO and H_2 according to the simplified formulas: $CH_4 + CO_2 = 2CO + 2H_2$ and $CH_4 + H_2O = CO + 3H_2$, in which formulas any parrafin can be inserted in the place of CH_4. These reactions occur probably at all times to some extent, but to make them really destructive the CO_2 and H_2O must be present in excessive quantities, which will happen when the fuel bed is thin and full of holes and channels. The steam-air blast will not have time to function properly; the gasification will be very uneven and the gas, in spots, contain principally CO_2, undecomposed H_2O and even oxygen. It is this gas rising through the channels that destroys the hydro-carbons and give the gas, when sampled in the main, the false appearance of being the result of a good gasification although the contrary is the case. The correctness of this theory we have proved through a series of gas samples collected inside the producer about a foot above the fuel bed, three short-time samples being taken simultaneously, one close to the side, one at the center and one half way in. As the time does not permit any detailed discussion of the very interesting results of the test, I will content myself with saying that the test covered all conditions possible, the fuel bed being deliberately allowed to take care of itself; that is to say, the producer was run at the ordinary rate without any poking, and with intermittent filling, so as to get an uneven fuel bed. It was found that when the producer was in a normal condition the three sets of samples averaged about the same, but that when channels were formed the sample from the periphery or the one from the center, and sometimes both, analyzed very low. Out of 155 sets of samples or 465 samples in all, 136 had a heat value below 80 Btu. and 82 less than 50 Btu. Of these 82 samples 67 had very high CO_2 contents, an average of 15.4 per cent, 5 had an average of 16.7 per cent O_2 and 10 about the same amount of CO_2 and O_2 (average 8.3 per cent CO_2 and 7.5 per cent O_2); in neither could any dissociation of steam have occurred. Comments are really superfluous; a gas of such a composition even though coming only from a small part of the fuel bed surface will necessarily have a disastrous influence on the volatile matter distiled off from a considerable area adjacent to the hole in the fuel bed.

Testing individual producers in this manner with three simultaneous samples at various points inside the producer will, without question, tell the condition of the fuel bed and the quality of the gas. We have found this method of testing to have a distinct practical value, particularly for mechanical producers. For example, having once reasons to suspect that the gas from a set of producers, although its analysis apparently was satisfactory, yet lacked in quality, gas samples were taken from all the producers in this manner. The center samples from one of the producers showed a very low Btu. value, indicating a thinner fuel bed at the center, due obviously to faulty coal distribution. The distributor was examined and a corner was found to be broken off; after repairs had been made the quality of the gas was restored to its normal high mark.

But while it thus is possible to judge the presence of the tarry vapors in the gas from gas analyses, the method imposes additional work on the laboratory and is not suitable for everyday routine work. I would, therefore, suggest the desirability of adopting another standard from which the quality of the gas could be judged. Formerly illuminating gas was measured by its candle power. With the advent of gas mantles and gas stoves the value of the illuminating power became of no consequence, while the heating power determined the quality of the gas, and the specifications were changed so that they stipulated a certain Btu. value for the gas, omitting any mention of the candle power. Reversely, I think that the producer gas should be judged by its luminosity and not by its heating value, at least where open hearths are concerned. It certainly would be a great help to the combustion engineers, if an instrument were designed that could measure directly the luminosity or the radiating power of the producer gas.

But returning to the discussion of the condensible hydro-carbons, which are distilled over into the gas, they consist, whether all or only a fraction remain in the gas, of tarry vapors and benzene with a constant percentage of carbon and hydrogen for a given kind of coal.

It is indeed an interesting coincidence—if nothing else—that the hydro-carbons in the coal which I have taken as a basis for my calculations, closely correspond in composition to naphthalene, C_1OH_8, because according to all authorities, napthalene is the predominant hydro-carbon compound that remains after the gas has been subjected to heat. It is itself not affected by any pyrogenetic reactions but is on the contrary the result of such reactions on other hydro-carbons. Professor Berthelot of Paris, the greatest authority on the subject, has among other pyrogenetic reactions produced the following ones:

$$\begin{aligned} 6\ CH_4 &= C_6H_6 + 9H_2 \\ 2\ C_6H_6 &= C_{10}H_8 + C_2 + 2H_2 \\ 5\ C_2H_4 &= C_{10}H_8 + 6H_2 \\ C_6H_6 + 2\ O_2H_4 &= C_{10}H_8 + 3H_2 \end{aligned}$$

In Appendix No. 6 I have set forth more in detail the figures proving this statement and calculations of the true volume of the waste gas from analyses when the presence of the condensible hydro-carbons are taken into account. From them is seen that while the tarry vapors in actual volume only represent one-quarter of one per cent, they nevertheless are responsible for 11 per cent of the heat value in the gas and for nearly 7 per cent of the waste gases.

Any calculations as to the products of combustion based on gas and waste gas analyses, would accordingly be misleading unless due consideration is given the tarry vapors. The exact amount of course we have no means of determining, but the assumption that, when the producers are operating normally, at least one-half of the tarry vapors are preserved in the gas will give a fairly corect result.

When applying the general formulas, that I presented in Section 2, to producer gas, the following corrections should be made:

$$\text{Formula 2 } w = \frac{y + v - o + 3}{x + z - q}$$

3 (cu. ft.) represents the amount of oxygen required by the tarry vapors per 100 cu. ft. dry gas.

$$\text{Formula No. 7: } CO_2 = w\,(h + 2j + k + m + 6n) - (a + 2b + c + e + 6f) - 2.5$$

2.5 (cu ft.) represents the amount of CO_2 produced from tarry vapors.

The necessity of entering the true volume of the water vapor in the waste gases into the calculations offers another difficult problem as it can not be determined directly, but involves a knowledge of the ultimate analysis of the coal and the amount of air used in gasification. It will never do arbitrarily to assume a value of the moisture that is contained in the producer gas and it is possible to derive at a figure that is sufficiently close so as not to introduce any perceptible error in the calculations. With regard to the moisture resulting from the combustion, one cubic foot should be added to the amount obtained through formula No. 8, this one cubic foot representing the water vapor produced by the combustion of the tarry vapors.

In conclusion I want to call attention to another fact which often is overloked: the necessity of two waste gas analyses when the problem concerns the combustion in an open hearth furnace, the question being whether the ratio between the gas and the air is correct or whether the combustion is performed in a satisfactory manner. When problems of this nature, involving the combustion in the furnace proper, are to be solved by means of gas analyses it will absolutely not do to collect the waste gas sample in the flue between the reversing valves and the stack because there always is a leakage of air into the downtakes and checker chambers and because there might be a short circuit in the gas reversing valve introducing combustibles in the waste gas. The sample must be taken as close to the furnace proper as possible—in the ports or downtakes. But due to the construction of the furnace, where the air and gas currents are introduced one above the other on more or less parallel lines and removed in a similar way, a perfect mixture is seldom obtained. A certain amount of gas will sweep closely over the bath; a certain amount of the air sweeps along the roof; between them is a separating blanket of waste gases and the result is that combustibles will show up in a waste gas sample collected from the gas downtake, while a simultaneously collected sample from the air-downtake shows free oxygen, indicating surplus air. Under normal operation, when the ratio between gas and air is close, this condition is more the rule than an exception. If only one sample is taken, either from the air or the gas downtake, the result must be erroneous; unless one sample from each of the downtakes is taken, simultaneously with a fuel gas sample (the sampling time of course in all three cases being inside a reversal or not more than 10-15 minutes) it is useless to attempt any calculations. It is naturally pre-supposed that the ratio in which the waste gases divide between the gas and air ports has been established by observations. This ratio is probably different from every furnace. In the calculations presented in Appendix No. 7 I have used a ratio of 45 per cent going through the gas ports and 55 per cent through the air ports, figures that we have obtained from actual measurement. These calculations show that the total amount of waste gases produced was 232.118 cu. ft., that the surplus of air was 10.4 per cent while the useful air amounted to 96.4 per cent of the air necessary for complete combustion. The ratio of heat development will figure to be 95.85 per cent. If we had contented ourselves with one waste gas analysis, we would have gotten, if we had taken our sample in the air port, 249.374 cu. ft. waste gases (or 7.4 per cent more than actually produced) as a result of complete combustion with a surplus of air as high as 27.2 per cent while, if the sample had been secured from the gas port, the result would have shown 214.018 cu. ft. waste gases (or only 92.2 per cent of the actual amount) with only 91.5 per cent of the possible heat developed because only 92.7 per cent of the necessary air were present.

It may seem inconsistent first to point out the mistake often committed by introducing assumptions in the calculations and then to try to prove my argument against ordinary producer gas analyses by means of an assumed quantity of tarry vapors existing in the gas. But my object was to show the great importance of the tar vapors not to produce a heatbalance. In the problems of combustion with which most of the time we have to deal, the question is not about the actual volumes nor of the total heating value, but simply whether the combustion is going on in an efficient way, and whether the proportion of gas and air is satisfactory. The calculations carried out according to my method and based on waste gas analyses collected at the gas port as well as at the air port simultaneously with a fuel gas sample will, under these circumstances, give a sufficiently close result, even though the presence of tar vapors and water vapors is neglected, particularly as the analyses are presented with only one decimal and it is perfectly satisfactory to compute the figures, on which the judgment is based, with one decimal only.

It has been the purpose of this paper to call your attention to the fact, that any guess-work can be eliminated from the solution of ordinary combustion problems by means of waste gas analyses, and to present a method that will extend the possibility of their application as it will establish the relations between a fuel gas and the waste gases even when the combustion is incomplete and part of the CO_2 is derived from the metal bath. I have confined myself to gaseous fuels, but the formulas can easily be modified to apply to liquid fuels as well, provided the assumption is made that they, during a certain stage of the combustion process, are gasified and dissociated into their elements. This assumption is of course in reality wrong, but as a purely theoretical chemical proposition it is permissible as the final result of the calculations will be the same.

It has furthermore been my intention with this paper to point out the error so commonly committed in judging the quality and the heating value of producer gas entirely from an analysis of the fixed gases it contains, neglecting the tary vapors, something that should not be excused with the inability to determine their amount. What is required is, that side by side of the gas analysis another standard be placed, based on the luminosity (candle power) of the gas. Should I have succeeded in convincing you of the soundness of my arguments and turning your attention towards this new direction, we will undoubtedly in a short time have a practical apparatus that will gauge the contents of tarry vapors in producer gas; and another step would then be taken forward to a more efficient application of fuel for metallurgical purposes.

TABLE 1—TABLE OF CHEMICAL REACTIONS IN COMBUSTION

One Cu. Ft.	Requires in Cu. Ft.		Produces in Cu. Ft.			Btu. Developed per Cu. Ft.	
	Oxygen	Air	CO_2	H_2O	N_2	High Value	Low Value
C_2H_4	3.0	14.286	2.0	2.0	11,286	1591	1491
CO	0.5	2.381	1.0	..	1,881	324	324
H_2	0.5	2.381	..	1.0	1,881	328	278
CH_4	2.0	9.524	1.0	2.0	7.524	1012	912
C_6H_6	7.5	35.715	6.0	3.0	28.215	3810	3494
C_2H_2	2.5	11.905	2.0	1.0	9.405	....	1437
$C_{10}H_8$	12.0	57.144	10.0	4.0	45.144	....	6070
H_2S	1.5	7.143	1.0(SO_2)	1.0	5.643	....	....

Internal Combustion Engines for Power Generation in Steel Plants

By D. M. PETTY*

THE internal combustion engines which will be described in this paper are the 4-cylinder, 4-cycle double acting gas engine and the 4, 6 or 8-cylinder, 2-cycle Diesel oil engine. The discussion in general will not go into thermo dynamic theory to any great extent, but will rather cover a general description of some of the mechanical features as well as the operation of the two types of engines, together with some analysis of first cost and cost of operation.

The Gas Engine.

The gas engine which forms the basis for this discussion is rated 4,000-kw. output of generator running at 88.3 rpm.

The floor space occupied is 68 ft. long and 37 ft. 6-in. wide; two cylinders are in tandem and connected to each end of the crank shaft. The distance between center line of cylinders is 27 ft. 8 in. It carries a very heavy cast steel flywheel made in two parts, the diameter of which is 28 ft. and weight 130 tons. The cylinders are 47 in. diameter. The piston has a 60-in. stroke; they are made of cast steel. In this particular size the cylinder is usually made in two pieces; however, in this size as well as in similar smaller sizes one-piece cylinders have been found entirely satisfactory.

In case of power cylinders of this size, steel rather than cast iron is employed because in order to maintain the same factor of safety the wall of the cast iron cylinder must be much thicker than if cast steel be used. The cast iron wall must on account of strength be made of a thickness so great that it cannot transmit the requisite heat per unit of surface. The consequent difference in temperature between inner and outer surfaces of wall induces heat fatigue and consequent cracks when engines are steadily operated at full load. A cast iron cylinder which thus cracks cannot be repaired by welding. A cast steel cylinder seldom cracks and if it does, can be electric welded without any difficulty. We have steel cylinders in our plant that have operated continuously 13 years and are still perfectly good.

The piston rod is 15 in. in diameter and is hollow, making a convenient opening through which the cooling water is carried to the piston. The crank shaft is a one-piece forging and the crank disc and crank pin are cast steel and made in one piece. The crossheads are also cast steel; the inlet and exhaust valves are one-piece forgings.

A great many of the above mentioned parts are frequently made of cast iron, but in the steel business cast steel is favored for obvious reasons, and since this engine is built by a steel company, cast iron is replaced by cast steel for a great many parts.

The speed of this engine is controlled by a spring weighted governor which operates an oil relay. This relay provides ample power for moving the valves, no matter whether they are clean or dirty, and is a very important item in the satisfactory operation of any engine used in the generation of power.

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*Electrical Engineer, Bethlehem Steel Company, South Bethlehem, Pa. Paper presented before Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, September 11-15. All discussions on this paper may be secured from J. F. Kelly, Secretary, Empire Building, Pittsburgh, Pa.

An automatic gas pressure regulator is located just ahead of the inlet valve and maintains a constant gas pressure of 2 in. at the inlet valve. The air mixture is adjustable, but is maintained constant throughout any range of load from zero to maximum unless adjusted by hand, the power output of the engine being governed by throttling the mixture of gas and air rather than by adjusting its richness. The maximum pressure in the cylinder after explosion is 275 lbs.

Fig. 1 shows a typical set of indicator cards on one of these engines.

The gas is ignited at the proper time by three spark plugs which operate on the make-and-break principle, 110 volts being the voltage and the current about .75 amperes. This current is limited by the resistance of the winding on an iron core solenoid which gives a long inductive arc, a small incandescent lamp is connected in series with the coil which serves to indicate the condition of the spark plugs.

An engine such as has just been described can be bought today, f.o.b. cars Bethlehem, for $230,000, making the cost of the engine $57.50 per kw.

Table 1 shows the installed cost per kw. of a gas engine power plant made up of three or more 4,000-kw. units as described above:

The only difference in this table from that shown in previous tables and published in the proceedings of the Association of Iron and Steel Electrical Engineers is in the cost of engine and related units, previous tables being made up on the basis of 3,000-kw. units. The larger unit which served as a basis for this table occupies the same floor space as that covered by the previous tables and costs but very little more, the principal difference being in the diameter of the cylinders.

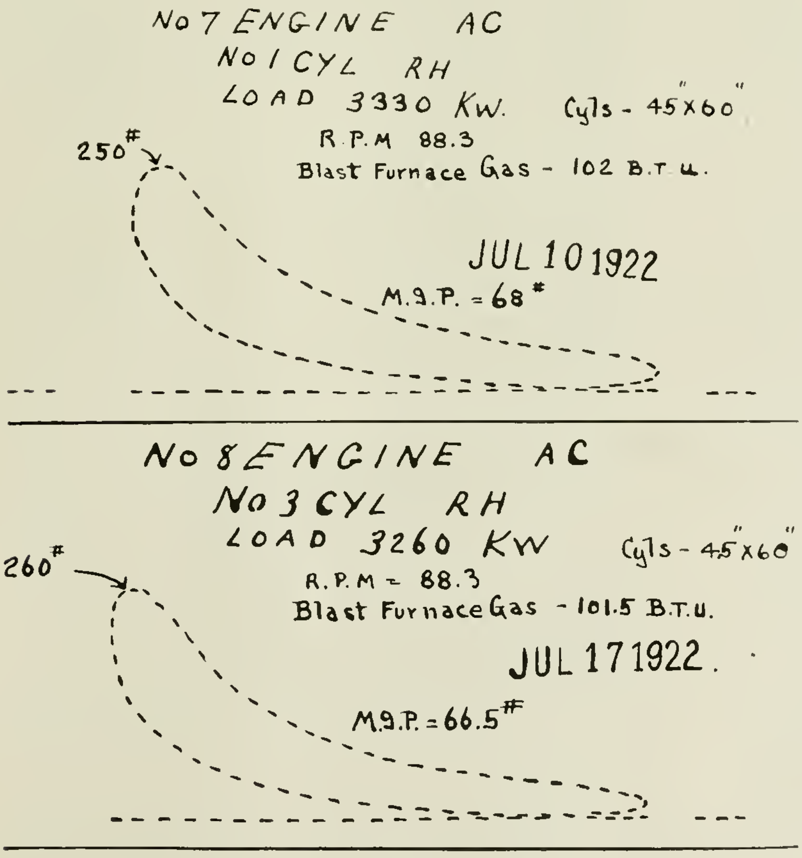


Fig. 1.

TABLE I

Showing installed cost per kw. capacity of a gas engine power station in 4,000-kw. units.

	Cost per kw.		
Building, modern construction, brick and steel, tile floors, and crane, including exhaust tunnel and stacks	$ 7.50	to	$ 15.00
Foundations for engines, including excavation at $15.00 per cu. yd.	4.50	to	9.00
Engines, including all piping painting ready to run	60.00	to	75.00
Gas cleaning apparatus	6.00	to	8.00
Generators, switchboard, exciters, oil switches for 6600 volts	13.00	to	20.00
Miscellaneous expenses	10.00	to	15.00
Total	$101.00	to	$162.00
Average cost per kw.			$132.00

The subject of gas engines should not be passed without calling attention to at least one of the points for future improvements in net operating efficiency, namely, the utilization of the heat contained in the exhaust gases. Reclaiming this energy is somewhat similar to the application of condensers to the steam turbine. This field is merely scratched today in a few plants where feed water for boilers is heated in a small way. The water enters the piston rod at about 100 deg. F. and comes out at 130 deg. F., passes to the feed water heater, where it is raised to 170 deg. F. Much greater economies may be obtained by placing a large boiler or water heater so that the exhaust gases may pass through it on its way to the stack.

One very great possibility lies in the heating of water which may in turn be circulated in nearby buildings and used for heating purposes. In Germany steam boilers have been used, one showing 2.2 lbs. steam for each kwh. generated by the engine. Large boilers will, of course, produce more steam. It has been very conservatively estimated that the total efficiency of the gas engine may be increased easily 30 per cent by the use of exhaust gas boilers.

The reason such boilers have not come into more general use is that the efficiency of the gas engine is now high and the cost of coal not sufficiently high to urge the development of this line of apparatus.

Operation of Gas Engines.

Table II shows the operating cost of a gas engine power plant made up of six 3,000-kw. units and one 4,000-kw. unit.

In the matter of operating costs one of the principal items in the past has been the renewal of worn steel parts, such as pistons, cylinders, piston rods, etc. This item has been very materially reduced by the careful application of electric welding. Formerly when the grooves of the piston became worn to such an extent as to cause excessive leakage by the piston ring all that could be done was to remachine them and put in oversized rings. This, of course, could not be carried on indefinitely on account of cutting away the metal. Today the worn places are filled up by electric welding and machined out so that the life of a steel piston is almost infinate. A cast iron piston cannot be thus welded.

TABLE II

	Cost per kwh.
Fuel—1,443,288,000 cu. ft. Average Btu value 94 per cu. ft. at .0094 per 1,000 cu. ft.	.00158
Labor—Including switchboard operators, engineers, oilers, superintendents, etc.	.00030
Repairs—Including renewals, tools, miscellaneous supplies and labor in repairs	.00033
Water for cooling—Oil, waste and packing, including cooling pond expenses.	.00021
Gas Cleaning—Including water, labor, repairs and power	.00037
Total operating cost	.00279
Heating feed water with exhaust gases (installed on 4 engines only) credit	.00033
Net operating cost	.00246

This table is practically the same as has been shown in previous discussions.

At times cracks develop in cylinder walls, especially in the vicinity of the exhaust ports, and formerly would necessitate the scrapping of the cylinder. Today these cracks are welded and seldom open up again; in fact, discarded cylinders have been reclaimed by this process to such an extent in one plant that four extra cylinders which were on order have been cancelled. It would seem, therefore, that with the proper application of electric welding a gas engine that is built of steel should never wear out and would be replaced only as a matter of obsolescence.

Diesel Oil Engine.

The Diesel oil enginge which will be used as the basis of this discussion is a 2,700-kw., 8-cylinder, 2-cycle, single acting vertical engine operating at 115 rpm.

The cylinder is 26 in. in diameter and the engine is built in sections so that it can be supplied as 4, 6 or 8-cylinder engine and all of the like parts for each cylinder are interchangeable. The pistons are cast steel while the cylinder is cast iron. The Scavenger air inlet valve is in the center of the cylinder head, which has the inherent advantage of cleaning out absolutely all of the burnt gases with the exhaust so that the compression stroke has a full supply of fresh air to compress each revolution. With this construction the Scavenger air supplied is always somewhat greater in volume than the maximum capacity of the cylinder.

A 6-cylinder engine corresponding to this engine is now in operation in a boat carrying ore from Chile to Baltimore and New York. The fuel economy, ease of operation and absence of serious failures has considerably exceeded the expectations of the designers, and from all tests which have been carried out the indications are that this type of Diesel oil engine will not only have a very wide application in marine service, but will also make a place for itself in the generation of power. An 8-cylinder engine such as described above can be bought today, f.o.b. cars Bethlehem, for $260,000.

The Operation of Diesel Oil Engines For Power Purposes.

While no costs are now available taken under actual perating conditions, tests which have been made bring out very forcibly some of the possibilities in the Diesel oil engine.

Fuel economy tests on this engine show that under average conditions one kwh. can be produced with .630 of a lb. of 21 deg. Baume fuel oil which oil contains 19,100 Btu. pre lb. This is equal to .438 of a lb. per bhp. Since 2,545 Btu. equal 1 hph., the thermal efficiency at the crank shaft then is:

$$\frac{2{,}545 \times 100}{438 \times 1{,}910} = 30.42\%$$

Assuming generator efficiency as 93 per cent, the overall efficiency of such a power unit would be: 30.42 × .93 = 28.47 per cent, the overall efficiency at the switchboard.

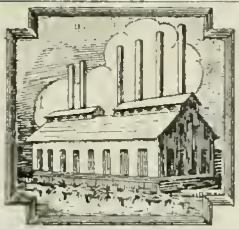
In the matter of speed regulation an 8-cylinder, 2-cycle Diesel oil engine is superior to the twin tandem compound reciprocating steam engine which would have the same power impulses per revolution, and while we cannot expect it to be equal to that of the steam turbine, it is very close to it. In this connection it is interesting to note that for marine work no flywheel is used in connection with even a 6-cylinder engine and the engine is reversible. Of course, for power generation a flywheel would be used, although much lighter than is the case with a gas engine.

Comparison of Internal Combustion Engines With Steam Engines for Power Station Work.

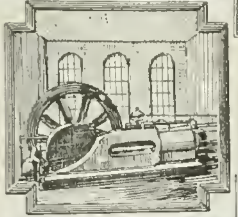
One great weakness of any steam power station is its standby losses. By this is meant in plainest terms the coal that must be burned under the boilers to keep up steam pressure when all of the power generating apparatus is absolutely shut down. This coal amounts to a considerable item and if it were possible to avoid burning this coal, great savings could be effected in practically all power stations. This particular point has been very forcibly brought to the writer's attention in the matter of selling power over week-ends and holidays to the power company from whom we normally buy a small percentage of our power.

The operating superintendent of the power company states that it is real economy for him to buy power provided he did not have to bank his fires, but could burn them entirely out, as under certain conditions it requires almost as much coal to keep his fires banked over a light load period, such as Saturday afternoon, Saturday night, Sunday and Sunday nights, as would be burned if he were running a portion of his plant. Therefore, he has seen the wisdom of buying power which is generated in our gas engine power station over such periods. We all feel that each power engineer has a moral obligation to coming generations in the matter of conservation of our fuel reserve. Therefore, the power engineer is not only serving his best interests, but also the best interests of future generations in taking into consideration standby losses.

In previous papers on the subject of "Power Generation in Steel Plants," the writer has pointed out the economy of using gas engines for all loads between 100 per cent and 50 per cent load factor and the fact that steam turbines either located in a steel plant or in a central station should be used for absorbing the low load factor portion of the steel plant load. It is now evident that the third alternative should be added to the list for this character of service, namely, the Diesel oil engine.



STEAM POWER DEPARTMENT



Blast Furnace Waste Heat Utilized

Steel Plant May Be More Economically Operated if the Waste Heat and Waste Gases from the Blast Furnaces and Coke Ovens Are Completely Utilized.

By HUBERT HERMANNS

Up to the end of the last century large gas-engines of 1,000 hp. were entirely unknown. In the year 1908 there were on the other hand more than 1,000,000 hp. of gas engines of over 1,000 hp. each in use all over the world. Of these there were:

			Pig-Iron Production
Germany	480,428 hp.	or 46.5%	at 11.8 mill. tons
U. S. A.	337,490 hp.	or 32.5%	at 16.2 mill. tons
France	55,050 hp.	or 5.4%	at 3.4 mill. tons
Belgium	46,714 hp.	or 4.6%	at 1.2 mill. tons
Austria	25,500 hp.	or 2.4%	at 1.4 mill. tons
Great Britain	24,986 hp.	or 2.4%	at 9.4 mill. tons
Other Countries	63,341 hp.	or 6.2%	

These figures comprise engines driven by blast-furnace as well as coke-oven gas and generator gas. The possibilities of the utilization of gases from blast-furnaces and coke-ovens were thus only utilized to a small extent. However these conditions have improved very considerably, so that the utilization of the gases is now considered as important as the production of pig-iron. Unfortunately reliable figures for the present time are not available. It is, however, certain that all pig-iron and coke producing countries have diligently worked at the solution of the problem within the last decade. In the following a representation of the possibilities will be given which the utilization of the gases generated in blast-furnaces and coke-ovens offers at the present time, the utilization of the waste heat being specially considered.

Fig. 1 illustrates the energy balance sheet of a blast-furnace of 250 tons daily with a coke consumption of 10 tons per hour. Of the heat of 100 per cent introduced into the blast-furnace 40 per cent is consumed in the furnace itself, while 60 per cent leave the furnace as waste gases. The consumption of heat is distributed as shown in Table I:

TABLE I

	Loss %	Gain %
Evaporation of the water	3	
Reduction of the ores	20	
Radiation	4	
Heat contained in the slags	10	
Heat contained in the iron	3	
Waste gases		60
	—	—
	40	60
	100	

The recovered 60 per cent of waste gases are distributed as follows:

Heating of the air blast		28
Of this heat developed in the furnace	14	
Loss	14	
Power required by the furnace		9
Of this current for the furnace	3.5	
For the blowers	5.5	
Excess of gases		23
	—	—
		60

Fig. 2 illustrates the energy balance sheet of a regenerative coke-oven with a generator for gasifying the coke dross. The balance sheet is based upon a battery of coke ovens for 200 tons daily output of coke, corresponding with a charge of 240 tons coal. Owing to the heating of the coke-oven the contents of heat is at first increased by 3 per cent, which however, is lost again later on by the cooling of the coke and the gases. The 100 per cent of heat introduced into the oven with the coal is distributed according to the following Table II:

TABLE II

	Loss %	Gain %
Coke output of the oven	75-83	
Gasification and combustion	5– 3	
Waste gases		22–14
	80–86	22–14
Distribution of the heat of the gases:		
Chemically combined with tar and benzole	1– 5	
Heating of the coke ovens	7–10	
Gases which can be utilized		6– 7
	8–15	6– 7

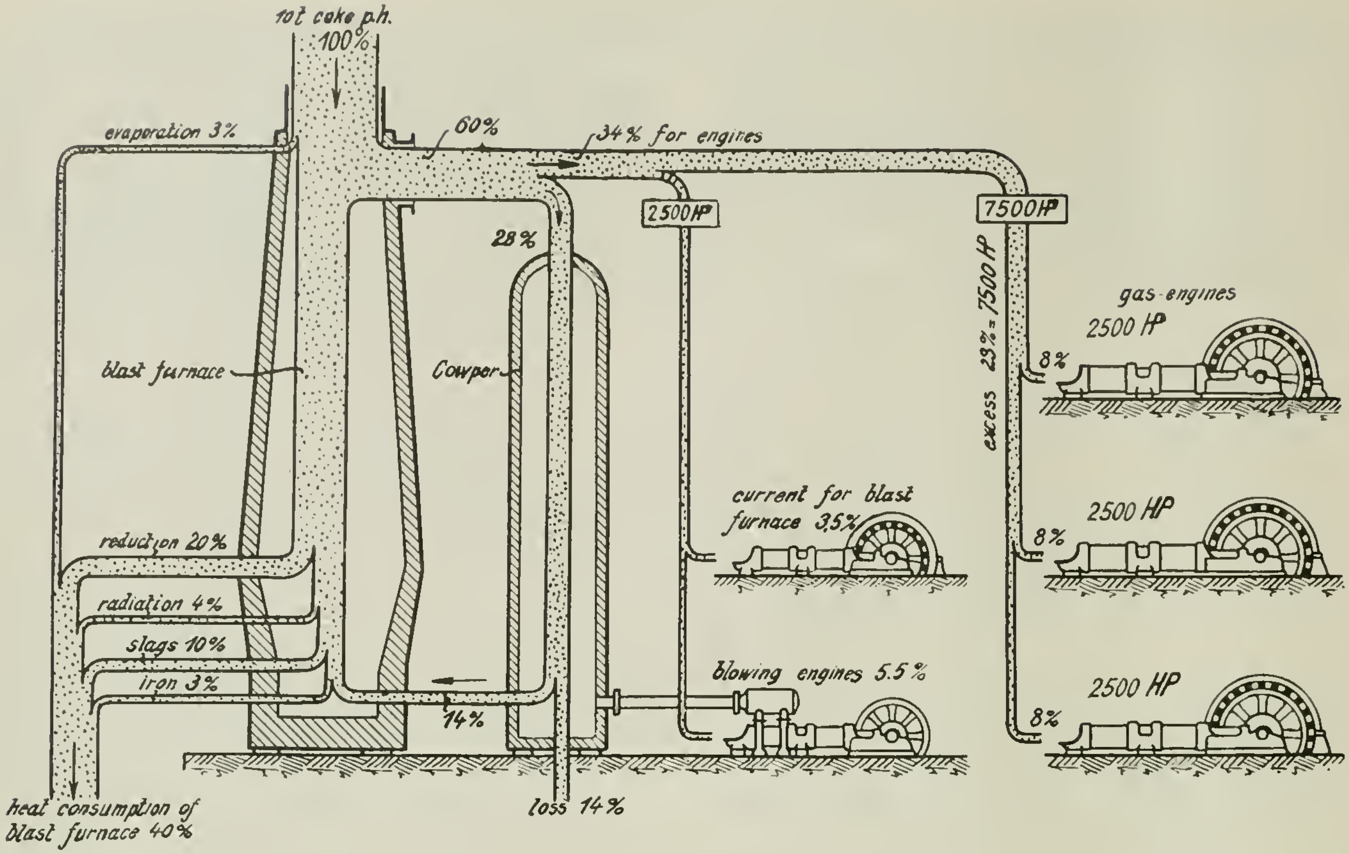


Fig. 1.

The 6–7 excess gases can be utilized in gas engines and would give a power of 1,800 hp. By gasifying the coke dross about 900 hp. can be recovered, so that about 2,700 hp. can be recovered in gas-engines from a battery of coke-ovens of 20 tons daily output. It is always a question of local conditions whether the coke-oven gas is utilized as fuel for heating furnaces or for driving gas engines. If there is a sufficient demand for the energy generated the use of gas engines in conjunction with coke-ovens can be recommended, be-

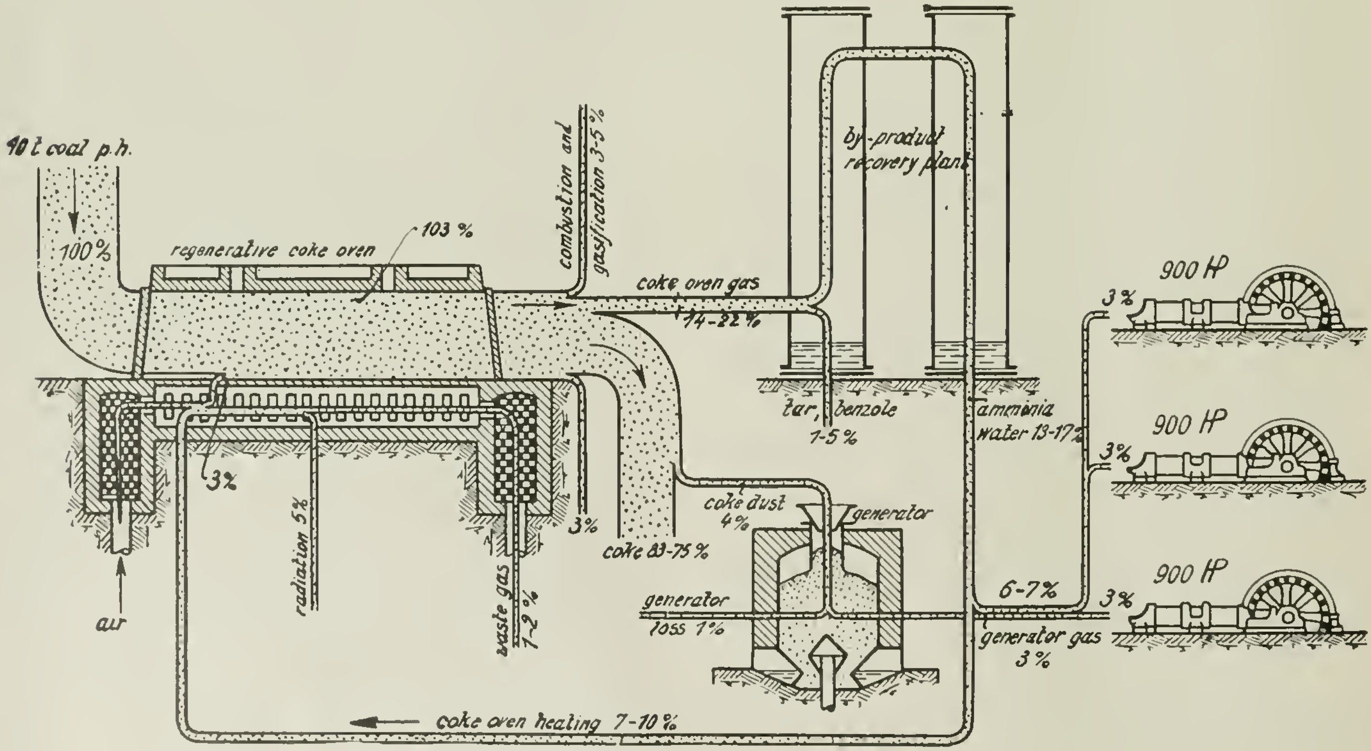


Fig. 2.

cause by the driving of such machinery the highest amount of energy can be withdrawn from the waste gases.

In the coke-oven industry the conditions for the employment of large gas engines are, therefore, not as favorable as in the blast-furnace industry, but the excess gases recovered more than suffice for their own requirements of the coal mines. The older constructions of coke flame ovens supplied their excess energy in the form of waste heat, which could only be employed for heating steam boilers. Ovens with by-product recovery installations without regenerative furnaces supply waste heat and waste gases. If the waste gases are burned in gas-engines instead of in boilers, the total engine output obtainable from the coke-oven is increased by about one-third. Regenerative ovens supply energy only in the form of coke-oven gas which in gas-engines produces double the amount of work as in steam boilers. The regenerative working of coke-ovens gives on the whole no higher quantity of energy than ovens with by-product recovery without regenerative furnace, which utilize their waste heat in steam plants and their waste gas in gas-engines, but their advantage is in the uniform kind of engine which can be employed and the simpler working conditions.

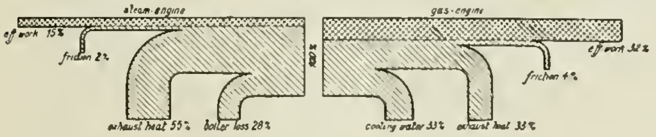


Fig. 3.

The internal combustion engine is far superior as regards conversion of heat into work to the steam plant. The gas engine has a heat efficiency up to 35 per cent, while the best steam plant hardly ever reaches 17 per cent.

In Fig. 3 the heat balance sheets of the steam engine and the gas engine are shown side by side.

Of 100 per cent heat introduced are consumed:

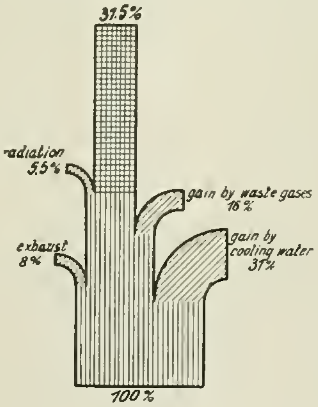


Fig. 4.

As this Table III shows in the gas-engine also large quantities of heat are lost in the exhaust gases and the cooling water. By employing waste heat utilizers in conjunction with the engines a large part of the waste heat may be recovered. In Germany very extensive experiences have been gained in this respect, as there the economical conditions peremptorily demand the most perfect utilization of the energy. Even in the year 1903 a gas-engine plant of more than 10,000 hp. was furnished with waste heat boiler for the generation of steam. However it is only since 1910 waste heat utilizers have been employed to a large extent.

TABLE III

	Steam-engine %	Gas-engine %
Loss in boilers..........	28	..
Waste heat	55	..
Friction losses	2	5
Cooling water	..	33
Exhaust heat	..	30
Effective work	15	32
	100	100

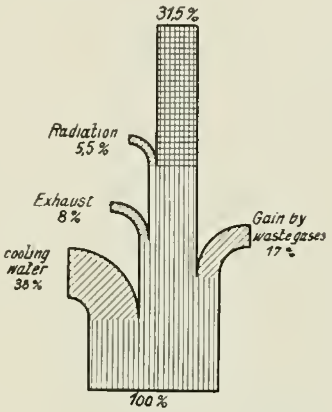


Fig. 5.

The waste heat from gas-engines and internal combustion engines may be utilized in various ways:

1. The cooling water which has become warm can be used for industrial purposes, in both installations, etc.
2. The warm cooling water can be further heated by waste gases and then be utilized for heating installations, boiler feed and the like.
3. Fresh water can be heated by waste gases.
4. Air may be heated by waste gases for drying purposes or drying chambers may be directly heated by the waste gases.
5. Water may be distilled by the waste gases.
6. Steam may be raised by the waste gases.

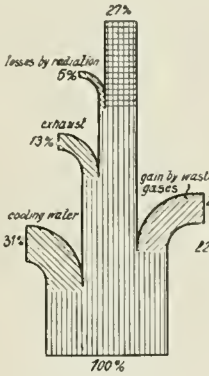


Fig. 6.

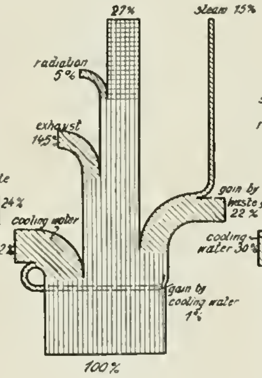


Fig. 7.

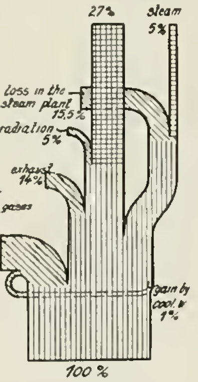


Fig. 8.

The gain produced by the recovery of waste heat fluctuates according to the possibilities of the utilization of the waste heat and the local conditions.

Figs. 4 and 5 show the fuel-utilization of a double-acting horizontal Diesel engine with a plant for the utilization of the cooling water and the exhaust gases; Fig. 4 in conjunction with the preparation of hot water in a closed circuit and Fig. 5 in conjunction with the raising of steam and the preparation of distilled water. The highest possible extent of the utilization (Fig. 4) which occurs in work, with a high demand for hot water (breweries, dye-works) amounts to about 84 per cent of the heat put into the engine. Individually the balance sheet figures in Figs. 4 and 5 correspond with the figures in Table IV.

TABLE IV

	Fig. 4.		Fig. 5.	
	Loss %	Gain %	Loss %	Gain %
Exhaust losses	8		8	
Radiation losses	5.5		5.5	
Cooling water losses			38	
Gain by waste gases		16		17
Gain by cooling water		39		..
Gain by engine efficiency		31.5		31.5
	13.5	86.5	51.5	48.5
	100		100	

Figs. 6, 7 and 8 show the conditions in a gas engine of 2,000 hp. with plant for preparing hot water for boiler supply, heating and so on (Fig. 6), in conjunction with the generation of high pressure steam for power purposes and utilization of the waste steam for chemical purposes (Fig. 7), and for the generation of power only. In Table 5 the balance sheet values are tabulated.

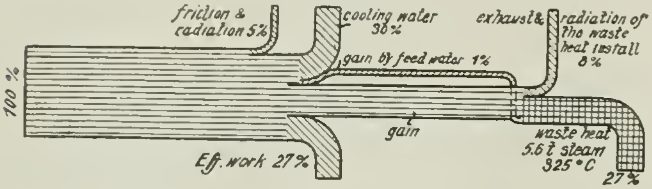


Fig. 9.

TABLE V

	Loss %	Gain %	Loss %	Gain %	Loss %	Gain %
Radiation	5		5		5	
Exhaust	13		14.5		14.5	
Cooling water	31		30		30	
Steam-raising plant						
Waste gases		24.7				
Waste steam				22		
Working steam				1.5	..	5
Engine efficiency		27		27	27	27
	49	51	49.5	50.5	50.5	32

Fig. 9 shows the heat balance sheet of a blast-furnace installation of 6,000 hp. with waste heat utilization, in which 5 or 6 tons of steam at 12 atm. and 325 deg. C. are generated. The output of about 0.93 kgs. steam per gas hp. per hour resulting according to Fig. 9 is obtained in gas-engines of medium sizes at full load, that means at the most favorable heat efficiency value of the engine.

At lower loads and less careful supervision the engine requires larger quantities of heat, which is mainly carried away by the exhaust gases and is recovered for the larger part by the waste heat utilization plant.

Table VI gives a balance sheet of this installation.

TABLE VI

	Loss %	Gain %
Friction and radiation	5	
Cooling water	30	
Exhaust and radiation in the waste heat installation	9	
Waste heat		29
Mechanical work		27
	44	56
	100	

PENN SEABOARD STEEL TO INCREASE ITS STOCK

A special meeting of stockholders of the Penn Seaboard Steel Corporation, Philadelphia, will be held September 29, for a vote on an increase in capital from 700,000 shares to 1,200,000 shares of stock of no par value. This is the same increase as proposed a few months ago when negotiations were under way looking toward the acquisition of the Carpenter Steel Company, Reading, Pa., although it is said these merger plans now have been abandoned. President J. B. Warren, of the Penn Seaboard Company, in a letter to stockholders declares the increase in capitalization is desired to enable the corporation to acquire further properties; to reduce materially or retire completely the corporation's funded debt; and to obtain additional working capital in order to properly handle increased business now on hand and in prospect. Penn Seaboard's capital was increased last November from 350,000 shares to 700,000 shares when the Titusville Forge property at Titusvile, Pa., was acquired.

TO DISMANTLE BAR MILL

Dismantling of the bar mill of the Carnegie Steel Company at Greenville, Pa., has been ordered and work of demolition will start at once. The Greenville plant has not been in use for the past four years and has a rated capacity of 96,000 tons of bars and small shapes. Operations were discontinued when the new mills of the company were started at McDonald, O. Most of the Greenville mployes moved to McDonald. Officials of the company recently inspected the plant and the order to dismantle followed. This is the second plant of the Carnegie Steel Company in the Western Pennsylvania district which is being scrapped. The North Works at Sharon, Pa., is being dismantled at the present time.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by Act of Congress of August 24, 1912]

Name of Publication: The Blast Furnace and Steel Plant, published monthly at Pittsburgh, Pa. [Report for October 1, 1922.]
Publisher—The Andresen Co., Inc., 108 Smithfield St., Pittsburgh, Pa.
Editor—D. N. Watkins, 108 Smithfield St., Pittsburgh, Pa.
Managing Editor—F. C. Andresen, 108 Smithfield St., Pittsburgh, Pa.
Business Manager—F. C. Andresen, 108 Smithfield St., Pittsburgh, Pa.
(Names and addresses of stockholders holding 1 per cent or more of total amount of stock:
Estate of H. A. Andresen, care Colonial Trust Co., Pittsburgh, Pa.
F. C. Andresen, 108 Smithfield St., Pittsburgh, Pa.
L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.
R. H. Thiess, 108 Smihfield St., Pittsburgh, Pa.
M. M. Zeder, 108 Smithfield St., Pittsburgh, Pa.
Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None
F. C. ANDRESEN, Business Manager
Sworn to and subscribed before me this 29th day of September, 1922.
JOHN N. ENGLISH, Notary Public
(My commission expires March 9, 1923.)

NEWS OF THE PLANTS

The Pacific Steel Corporation, San Francisco, Cal., recently organized under Delaware laws with a capital of $20,000,000, will comprise a consolidation of the Pacific Coast Steel Company and the Southern California Iron & Steel Company, as well as other iron and steel concerns now operating on the Pacific Coast, and whose names will be announced at a later date. The new company will also take over the iron ore properties of the Milner Corporation in Utah. The first noted company, the Pacific Coast Steel Company, operates plants at San Francisco and Portland, while the Southern California Company has its works at Los Angeles. Plans are now being perfected for extensive additions and improvements in these works, including the installation of additional equipment for increased output. A large new plant for the production of pig iron will be established on a site to be selected in Utah; this works will comprise blast furnace, mills, power plant, etc., and is estimated to cost in excess of $5,000,000. The new corporation is represented by T. T. C. Gregory, Insurance Exchange Building, San Francisco.

The Meadville Malleable Iron Company, Mill Street, Meadville, Pa., has taken bids for the erection of a new brick and steel addition to its plant, to comprise a one-story building, equipped as an annealing works. It is planned to commence the construction at an early date. Shutts & Morrison, Marine Bank Building, Erie, Pa., are architects in charge.

The Wickwire-Spencer Steel Corporation, Worcester, Mass., has arranged for a note issue of $1,775,000, the proceeds to be used for proposed extensions and general expansion, as well as financing in connection with the acquisition of the plant and business of the American Wire Fabrics Company, with mills at Mt. Wolf, Pa., and Blue Island, Ill. The corporation is also operating other plants at Worcester, Spencer, Palmer, and Clinton, Mass., as well as at Buffalo, N. Y. Plans are being arranged for the immediate rebuilding of the portion of the mill at Spencer, recently destroyed by fire with a loss estimated at close to $40,000, including equipment. The new mill section is estimated to cost approximately a like amount; it will be three-story, 33x100 ft.

The Bethlehem Steel Corporation, Bethlehem, Pa., has commenced preliminary work for the proposed expansion of its plant at Sparrows Point, Baltimore, Md., for which a fund of $3,500,000 recently was authorized. The work will include an addition to the present No. 2 open hearth furnace, comprising a 250-ton tilting furnace unit, to make a complete operating unit of five 250-ton open hearth furnaces. The present five stationary furnaces, each of 70-ton capacity, will be augmented with four new 100-ton units, bringing about an increased ingot production of about 400,000 tons a year, total. A new power plant will be constructed at the mill, with initial installation of a 10,000-kw. turbo-generating unit, with new boiler plant, steam condensing department, etc., to be operated as an auxiliary to the present gas engine station.

The Crucible Steel Castings Company, Canal Road, Cleveland, Ohio, will commence the immediate erection of a new plant at Almira Avenue and East Eighty-second Street. It will be one-story, 100x240 ft., and is estimated to cost close to $100,000, including machinery. The general building contract has been awarded to the Samuel W. Emerson Company, Euclid Building, Cleveland. G. S. Rider & Company, Century Building, Cleveland, are architects and engineers.

The Ohio Steel Products Company, Mineral Ridge, Ohio, is perfecting plans for the sale of its local plant, which has been inactive for some time past. The company has been operating with a capital of $500,000, engaging in a general line of steel production. It is said that negotiations are under way for the purchase of the property, and that the prospective new owners plan to place the works in service at an early date.

The Rich Steel Products Company, Battle Creek, Mich., has preliminary plans in progress for the erection of a new plant, on local site, to be equipped for the production of a general line of steel products. The new plant will be one and two-story, and is estimated to cost in excess of $350,000, including machinery. It is expected to perfect the details of the new mills by the close of the year and to break ground for the structures early in 1923. The company is now operating a plant on Springfield Place, Battle Creek, and it is said will remove this works to the new location following the completion.

The Standard Seamless Tube Company, 313 Sixth Avenue, Pittsburgh, Pa., has preliminary plans in progress for the construction of an addition to its plant at Ambridge, Pa., for increased production. The structure will be one-story, 80x500 ft

The Belle City Malleable Iron Company, Kewaunee Street, Racine, Wis., has completed plans and will commence the immediate construction of a new plant on local site for the manufacture of a general line of iron products. The works will be one and two-story, 80x100 ft., and are estimated to cost about $75,000. A list of equipment to be installed will be prepared at an early date. The company will establish headquarters at this location and will build an office building for this purpose.

The Morristown Electric Steel Company, Inc., 13 Water Street, Morristown, N. J., recently organized, has acquired the former plant of the Liberty Steel Company in the Shelley Terminal District, and will take immediate possession for its proposed works. The present structure will be remodeled and improved, it is stated, and considerable new equipment installed for electric steel production. The new company is headed by Samuel B. Illingsworth and J. Lovel Paulmier, both of Newark, N. J., and Richard A. Eurich, Morristown.

The Electrolytic Iron Company, Bridgeport, Conn., recently organized, has acquired the plant at Milford, Conn., formerly occupied by the Page & Nettleton Company, situated on New Haven Avenue. The new owners plan for the immediate establishment of a new works for the production of pure iron by the electrolysis process, and complete equipment for this purpose will be installed. The present factory building will be remodeled and improved to accommodate the new industry. The works will include an extensive testing laboratory.

The Damascus Crucible Steel Castings Company, New Brighton, Pa., has acquired a tract of property at Hammond, Ind., fronting on the Nickel Plate railroad lines, totaling about 10 acres of land. The tract will be used for the erection of a new plant, for which plans will be placed in progress at an early date. It is expected to equip the initial buildings to give employment to a working force of about 300 men. Bids will be asked for construction, it is said, at an early date, and a list of machinery to be installed will be arranged. The estimated cost of the project has not, as yet, been announced.

WITH THE EQUIPMENT MANUFACTURERS

NEW BLEEDER TYPE TURBINE

Increasing competition demands lower manufacturing and operating costs and better steam economy in every industrial plant. Heretofore, as would be most natural, especial study has centralized upon the large power installations and the smaller plant has not made the same progress toward economical operation that has been perfected in the plant many times larger.

In line, however, with a desire to decrease operating costs in the average size industrial power plant, the Moore Bleeder Type Turbine has been thoroughly perfected and placed upon the market. It fulfills a long felt want wherever steam, after generating power, is used for heating buildings, heating feed water for boilers, manufacturing and cooking. It solves in a satisfactory manner the problem of heat balance and acts as a reducing valve for converting high pressure steam to a lower desired pressure, meanwhile extracting the energy due to the heat drop.

It is simple in design, easy to "get at" and automatically regulates perfectly, either for varying power conditions or fluctuating demands for exhaust steam. The efficiencies obtained have proven exceedingly gratifying. One operator, for instance, who had bought outside power at $600 per month, yet who had generated steam in his boilers at 125 lbs. per sq. in. and reduced it to 40 lbs. per sq. in. through a reducing valve, for cooking purposes, found that a Moore Bleeder Turbine could take the place of the reducing valve, generate his power requirements and fulfill his demand for exhaust steam. He saved $600 per month, which in less than a year paid for the turbo-generator. There are doubtless many operators today who could follow the same procedure with resulting greater efficiencies and lower operating costs.

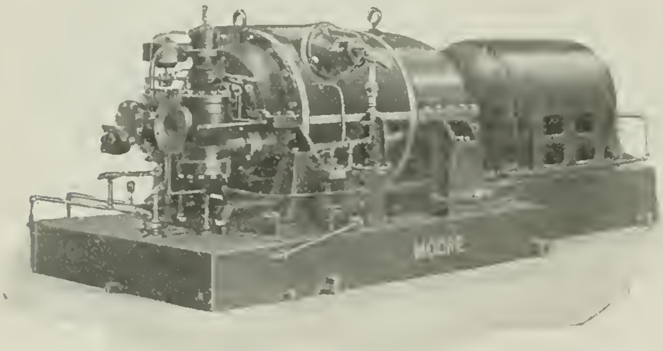


FIG. 1. BLEEDER TURBINE FROM BLEEDER VALVE SIDE

The general design of the Moore Bleeder Type is that of a multistage turbine, with one or two velocity stages followed by a number of pressure stages. Between the velocity stage and pressure stage is the bleeder chamber "A," Fig. 2, which connects to the heating or cooking system. The cylindrical bleeder valve allows excess steam to enter chamber "B," from which point it flows through the pressure wheels to the condenser.

An oil relay governor controls the turbine speed. A cylindrical bleeder valve controls the steam flow rate to the bleeder exhaust.

Since the bleeder type serves as a combination non-condensing high pressure condensing turbine, it effects a close heat balance, even where there are only one or two main units. The flow of steam to a heating system being determined by the pressure of that system, the load to be carried by the high and low pressure elements, in order to result in the proper heat balance, is automatically determined by the cylindrical bleeder valve which regulates the flow of low pressure steam to the heating system. The oil relay governor automatically regulates the flow of high pressure steam to the high pressure stages to meet changing load conditions. Hence with these two simple and positive equalizers a perfect balance is automatically maintained.

Among the claims for the Moore Bleeder Turbine, with its cylindrical valve, may be mentioned the following:

The cylindrical type of valve gives a wide, unobstructed opening with minimum pressure drop from "A" to "B." (A drop between these two points means loss in efficiency.)

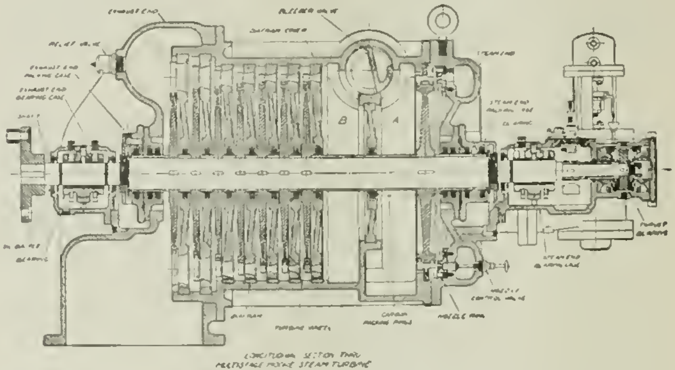


FIG. 2. CROSS SECTION OF MOORE BLEEDER TURBINE

The weight of the valve, together with the thrust due to steam pressure, is carried on two large bearings, one at either end. Very little effort is required to turn the valve.

The bleeder valve clearance is greater than the end bearing clearances. This not only makes for easy rotation of the valve, but likewise allows a small quantity of high pressure steam to leak past the valve into the low pressure stage. This prevents high temperatures which occur due to windage friction of the rotating elements in the surrounding thinned out steam.

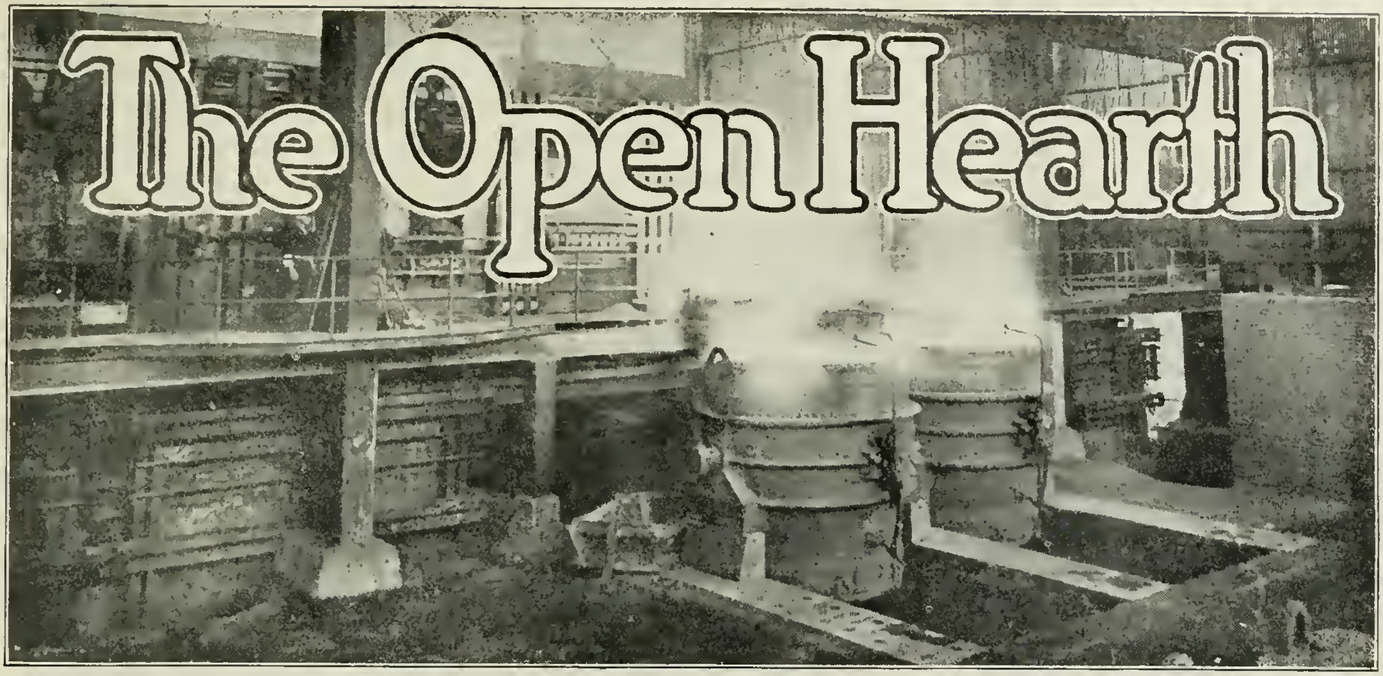
The entire bleeder valve can be quickly removed without disturbing or dismantling the casing.

The valve forms part of the turbine casing, thereby presenting a compact appearance.

The valve arrangement has only a few parts and requires little attention.

The Moore bleeder turbine is built for initial pressures as low as 100 lbs. per sq. in. and bleeder pressure as high as 40 lbs. per sq. in.

The Open Hearth



Harry W. Irwin recently resigned his position as superintendent, which occupation he has held for several years, at the plant of the Canton Sheet Steel Company, Canton, Ohio, to become superintendent of the Universal Steel Company, Bridgeville, Pa. Mr. Irwin went to Canton in 1901 and became identified with the Stark Rolling Mill Company.

V V

John Leyshon, who resigned recently his connections with the Gary, Ind., plant of the American Sheet & Tin Plate Company, to become general manager of the India Tin Plate Company, Galmuri, India, was scheduled to sail during the week of September 1 for London, thence via Suez canal for India. Mr. Leyshon formerly was employed at the Farrell, Pa., works of the American company. D. W. Samson is to be hot mill superintendent at Gary.

V V

A. W. Ambrose will become assistant director of the bureau of mines, October 1, succeeding E. A. Holbrook, who has become dean of the mining school of Pennsylvania State College. Mr. Ambrose is now chief petroleum technologist of the bureau. He is a graduate of Stanford University and has been with the bureau since 1917. F. J. Bailey, assistant to H. Foster Bain, director, and a graduate of Middlebury College, Vt., will handle all of the business matters of the bureau formerly under the assistant director, thus permitting Mr. Ambrose to supervise the petroleum activities of the bureau in a general way.

V V

J. Brynmor Hill, director Gorsienon Steel & Tinplate Works, Swansea, Wales, who recently spent several weeks in this country in visiting steel plants, was a passenger on the Majestic, which sailed from New York, August 26.

V V

A. G. Douglas, chief engineer, and W. H. Mortlock, production manager, Hoskins Iron & Steel Company, Ltd., Lithgow, New South Wales, Australia, recently visited the plant of the St. Louis Coke & Chemical Company, Granite City, Illinois. These gentlemen are visiting a number of representative iron and steel plants in this country and Canada for the purpose of familiarizing themselves with American practice.

V V

H. H. Harris, formerly with the Union plant of the Bethlehem Shipbuilding Corporation, has been appointed assistant manager and chief engineer of the Hanlon Drydock & Shipbuilding Company, Oakland, Cal.

V V

Walter Rachals, assistant to chief engineer of the United States Steel Corporation, returned September 14, following a visit of several months in England, France, Belgium and Germany.

V V

F. M. Mitchell, assistant general manager of the Broken Hill Proprietary Company, Ltd., steel works, New South Wales, Australia, recently arrived in this country and is visiting steel plants in the Pittsburgh, Chicago and other producing centers. Mr. Mitchell expects to leave San Francisco for Australia on November 10.

V V

John W. Porter, vice-president of the Alabama Company, who has been resting from his duties for several weeks, nas returned to Birmingham and is again at his desk fully restored to normal health.

V V

D. J. Felkel recently resigned as superintendent of the Covington, Va., blast furnace plant of the Low Moor Iron Company to become connected with the blast furnace department of the Cia. Fundidora de Fierro y Acero de Monterrey, S. A., Monterrey, N. L., Mexico, in the same capacity.

V V

George B. Waterhouse, metallurgist of the Lackawanna Steel Company, has been secured by the Massachusetts Instistute of Technology, Boston, to take charge of the metallurgical lines. Dr. Waterhouse has resigned his connection with the Lackawanna company, and will take up his new duties with the opening of the fall term at the Institute. He has been with the Lackawanna company for 16 years.

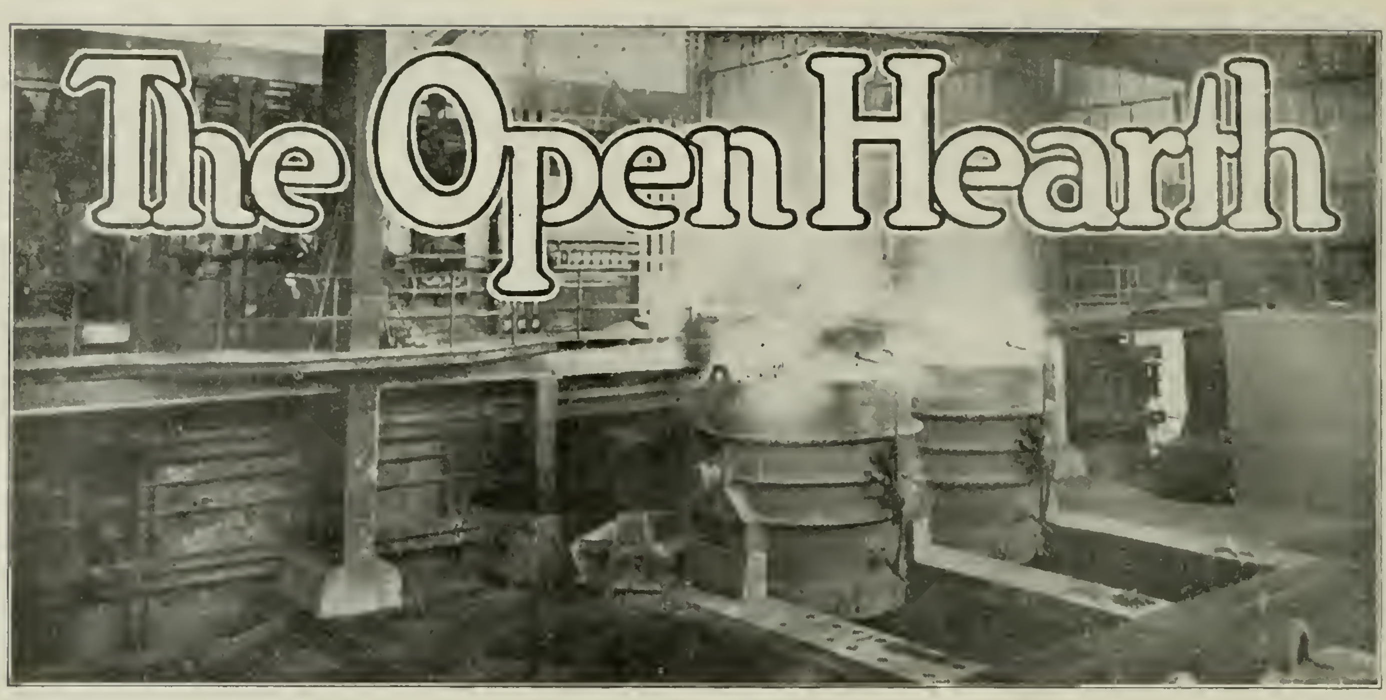
V V

John J. Whiting has resigned his position as assistant manager of the Mayville Plant of the Steel & Tube Company of America to accept the position of superintendent of blast furnaces of the Donner Steel Company, Buffalo, N. Y., and Tonawanda, N. Y.

V V

W. S. Rugg, assistant to vice-president, Westinghouse Electric & Manufacturing Company, has been appointed to the newly created position of general manager of sales of that company.

The Open Hearth



J. Fred Townsend, traffic manager of the National Tube Company, Pittsburgh, has been elected vice-president of the Lake Terminal Railroad, the McKeesport Connecting Railroad and the Benwood & Wheeling Connecting Railway, subsidiaries of the National Tube Company.

* * *

Gustavus Pratt has been in the employ of the Stanley Works, New Britain, Conn., for 60 years. Mr. Pratt's father was employed in the same company for 65 years, the combined service being 125 years. In these times of unusual labor turnover, this record of long and efficient service is noteworthy.

* * *

John Goodin Carruthers, for more than three years district manager of sales for the Illinois Steel Company, at Chicago, leaves that position October 1 to become general manager of sales for the Otis Steel Company, at Cleveland. He will be succeeded by David Buffington, who has been in the general sales department of the former company for many years.

* * *

Owen K. Parmiter, metallurgist, Firth Sterling Steel Company, McKeesport, Pa., was the speaker at the monthly meeting of Pittsburgh Chapter, American Society for Steel Treating at the William Penn Hotel, Pittsburgh, Tuesday evening, September 5. His subject was "Stainless Steels."

* * *

Col. C. H. Crawford, South American manager of the Baldwin Locomotive Works, and Clifford Shoemaker, Washington, have been appointed representatives of the American Association of Engineers at the International Engineering Congress held this month at Rio de Janeiro. The purpose of the conference is to establish closer contact among those engaged on problems of economic progress in all the Americas.

* * *

Frank B. Worrilow recently resigned as superintendent of the Millbury Steel Foundry Company, Millbury, Mass., which position he has held for the past five years, to become associated in the same capacity for a foundry in Pittsburgh.

* * *

A. D. Neal, recently connected with the roll department of the Duquesne Steel Foundry Company, Pittsburgh, and formerly identified with the sales department of the Carnegie Steel Company, Homestead, Pa., has been added to the sales force of the Pittsburgh Rolls Corporation, Pittsburgh.

* * *

The United Alloy Steel Corporation, Canton, Ohio, recently made a number of changes in their organization. H. C. Thomas was promoted from general superintendent to assistant general manager; J. B. Thorpe was appointed general superintendent of the Alloy Division, and H. T. McBratney, general superintendent of the Sheet Division. Mr. Thomas and Mr. Thorpe were formerly connected with the Gary Steel Works of the U. S. Steel Corporation, the former as assistant general superintendent and the latter as open hearth superintendent, both going to the United Alloy Corporation in 1918. Mr. McBratney was for a number of years general superintendent of the sheet mills of the Allegheny Steel Company, Breckenridge, Pa.

* * *

B. D. Quarrie, vice-president and general manager of the Otis Steel Company, Cleveland, has been elected director of the Guardian Savings & Trust Company, that city.

* * *

W. H. Ryan, for many years associated with Pratt & Letchworth Company, Buffalo, has accepted the position of superintendent of the Malleable Department of the Superior Steel Castings Company, Benton Harbor, Mich.

* * *

J. C. Peil, formerly superintendent of foundries, Maxwell Motor Company, Dayton, Ohio, later in a like position with the Rumley Company, La Porte, Ind., has taken an interest in the Ypsilanti Motor Castings Company, Ypsilanti, Mich., and has become superintendent of that company.

* * *

Robert C. Yates, for many years identified with the Union Drop Forge Company, Chicago, has resigned to become associated in the capacity of general manager of the Interstate Drop Forge Company, Milwaukee, Wis. Mr. Yates, after graduating from Union College, was connected with the American Locomotive Company, at Schenectady, N. Y., and Bethlehem Steel Company, having also been manager for a time of the Chicago district office of Bethlehem. The Interstate Drop Forge Company, which was organized in 1919 for the manufacture of small commercial forgings, is closely allied with the Chain Belt Company, Sivyer Steel Casting Company, and Federal Malleable Company, all of Milwaukee.

Some Pointers on By-Product Coke Oven Operations

COKING PROPENSITIES OF COAL

The results of investigations, carried out during the last five years in the fuel laboratories of the Imperial College of Science and Technology, into the resinic constituents of bituminous coals and their supposedly determining influence upon coking propensities, indicate that strongly-coking bituminous coals may be extracted for prolonged periods by organic resin-solvents without impairing their coking propensities.

The pyridine-chloroform method of extracting coals yields an admixture of resins with a predominance of non-resinous substances, chiefly of callulosic origin. The resins may be extracted and isolated in a pure condition from such coals by the pyridine-amyl alcohol treatment, with successive treatments with ethyl ether and light petroleum. These resins, however, do not generally exceed 1 per cent of the coal substance and are not a chief cause of the coking propensities of coals.

A series of non-resinous substances, mostly insoluble in ether, but soluble in chloroform, are also obtainable by the above mentioned treatments. They amount to as much as 4 per cent with strong coking coals. These non-resinous substances, upon being heated out of contact with air, give a strong exothermic reaction between 275 deg. and 375 deg. C., accompanied by the elimination of water. This shows them to be cellulosic in type and origin.

It is shown that the coking propensities of coals are principally due to the presence of such non-resinous substances of cellulosic origin, whose fusion temperatures are below those at which they undergo rapid decomposition; furthermore, the more complex substances, also of cellulosic origin, which form the main portion of the coal substance, but which decompose without fusion, have little or no direct influence upon its coking propensities.

LOW TEMPERATURE CARBONIZATION OF COAL

While referring to the aims and advantageous results anticipated from low temperature carbonization of coal, the author comments upon its success from an economical point of view. Hitherto, it has been far from a paying proposition.

Difficulties in the past have been threefold, viz., the swelling of the charge, the long period of carbonization required, and the unmarketable quality of the fuel, due to its friability. A knowledge of the chemical constitution of coal would appear to be the keystone of the problem, and investigations have been made by the author in this respect.

He discusses the properties of the four main types of substance of which coal consists—the alpha, gamma, beta, and ulmin compounds—and a sketch gives a classification of the various types of coal, conditioned by the amounts of the four ingredients in question, and by the relative amounts of the various types of beta and gamma compounds. Here is shown in a qualitative manner the variation in composition of the various types of coal, with quantitative results.

The divers stages of coke structure are described. Temperature gradient and plasticity of the coal mass are important points for consideration, and the author demonstrates that one-stage coals are practically responsible for fairly good, low temperature coke. It is the natural one-stage coal, where the gamma compound is decomposed between a short interval of temperature, which can be carbonized at low temperatures with some degree of success.

"CHANCE" PROCESS OF FLOTATION

A new flotation process, which bids fair to modify greatly the methods now employed in the preparation of anthracite, has been designed by Mr. T. M. Chance, of H. M. Chance & Company, Philadelphia.

The machine utilizes a mixture of fine sea sand and water The maximum specific gravity obtainable with these substances will closely approximate that of the sand itself, while it may vary from this down to unity, or the specific gravity of the water used.

Illustrations show plans designed for a new type of preparation plant, utilizing the new kind of separation machine, destined for a building 129 ft. in height. The operation of a double preparator, with a capacity of 2,000 tons of coal per day, the feed being 3,300 tons (40 per cent of which is refuse), requires 41 men. The cubical contents of the structure will be 670,000 cu. ft., and the volume per ton of daily capacity will be 335 cu ft. Preliminary estimates show that a building of this type and size would require 475 tons of structural steel.

The mode of operation is minutely described, from which it would appear that the division of the coal from the slate or bone is done before the coal is sized. When the coal flows over from a cone, it is screened into egg, stove, nut, pea, buckwheat and birdseye, and the fine sand it removed. The refuse falls to the bottom of the cone, is trapped in a chamber having an upper and lower gate, provided with an interlocking device, preventing the two being opened at the same time, and is transported to a chute by a refuse conveyor.

SILICA BRICK FOR COKE OVENS

The British practice of using quartzite brick was referred to in a recent paper read before the Coke Oven Managers' Association. The author urges the necessity for seriously considering, in the case of erection of new ovens, whether silica brick should not be used instead of the present generally utilized quartzite. The advantages show that with the former quality of brick, higher temperatures, greater output, and greater thermal efficiency are obtainable. At high temperatures, its conductivity is considerably superior, and instances are quoted, where the future general use of silica brick is predicted.

It is suggested that there is no sacrifice of by-product yield, and as regards durability, most favorable results are shown by ovens built of silica brick. Corrosion of the walls, which frequently happens where salty coal is used, would be avoided by the employment of silica, and no clearer or more convincing evidence could be cited in the latter's favor than where two batteries of coke ovens, respectively built of silica and quartzite, were working side by side. The former lasted six years, while the latter required rebuilding after three to nine months.

A matter of importance is the property which silica brick posssesses of expanding permanently, and when working at high temperatures care should be taken to select a brick of which the permanent expansion is low.

Reference is made to the crystal modifications of silica, which, on account of the accompanying tremendous changes in volume, should take place in the kiln, and not in the oven. A table shows the changes which take place when silica brick is heated.

Ganister or quartzite, suitable for a first class brick, should not contain less than 97 per cent silica, and an ideal composition is mentioned. Physical properties are equally as important, and it is not advisable to use a brick with a higher specific gravity than 2.35.

TRADE NOTES

The Consolidated Gas Electric Light & Power Company of Baltimore has placed order with The U. G. I. Contracting Company of Philadelphia for two U. G. I. tar extractors, each having a capacity of 6,000,000 cu. ft. per day. The latter company has also received orders to install two similar tar extractors at the Langsdale Avenue plant of the Citizens Gas Company of Indianapolis, and one tar extractor of 4,500,000 cu. ft. capacity at its Prospect Street plant.

F. J. Ryan & Company, Wesley Building, Philadelphia, Pa., industrial furnace equipment specialists, announce the recent receipt of contracts for furnace equipments from the following concerns: American Fork & Hoe Company, Milton Manufacturing Company, Crucible Steel Castings Company, Cleveland, Ohio; Davis Brothers, New Process Metals Corporation.

The Power Specialty Company, 111 Broadway, New York, announces the appointment of Pell W. Foster, Jr., as New England district manager, with offices at 50 Congress Street, Boston. Mr. Foster was formerly in the New York sales office.

The Chicago Flexible Shaft Company, Roosevelt Road and Central Avenue, Chicago, has opened a new district sales office, with headquarters at 305 Merchants Bank Building, Indianapolis, to handle furnace sales in Southern Ohio and Indiana, and Western West Virginia. F. W. Odemar is in charge.

Alfred Box & Company, Inc., Philadelphia, electric and hand cranes and hoists, opened a factory branch office at 30 Church Street, New York, on September 15. N. C. Failer, an engineer who has specialized in handling these lines, is in charge. This is the beginning of a plan to establish direct factory branches in a number of large business centers.

The Economy Fuse & Mfg. Company, Greenview Avenue, Chicago, has moved its Detroit sales office from 1012 Majestic Building to 1528 First National Bank Building.

The Diamond Chain & Mfg. Company, Indianapolis, announces the opening of an office at 340 Leader-News Building, Cleveland. H. I. Markey, for five years mechanical engineer with the Diamond Chain Company, will be in charge.

The United States Coal & Coke Company, Gary, W. Va., are going to use bone coal, which was formerly considered waste, as a boiler fuel. To this end they are installing in their new plant two 46-in. Fuller-Lehigh screen mills for pulverizing coal, Fuller-Kinyon distributing system for conveying the pulverized coal from the mills to the furnace bins and each 800-hp. boiler will be equipped with five vertical burners, taking the fuel from five 3-in. screw feeders.

TRADE PUBLICATIONS

The Bristol Company, Waterbury, Conn., have issued a new 68-page catalogue devoted to Bristol pyrometers. The catalogue is very profusely illustrated and contains very valuable condensed information on the subject. The catalogue is No. 1401 Bristol's Pyrometers.

F. J. Ryan & Company have recently issued Bulletin 4A, entitled, "Liquid Fuel Burning for the Generation of Steam." It is very interesting and will be sent upon request.

The Brown Instrument Company have issued a new Catalogue No. 85 on the automatic control of temperatures through Brown indicating and recording instruments.

One of the most interesting publications of the year in the mechanical stoker field is the new bulletin, "Cutting the Cost of Producing Steam," just published by the Detroit Stoker Company of Detroit, Mich. The bulletin starts with the premise that "One of the conditions necessary to the efficient combustion of coal is the uniform liberation of the volatile gases. This is a condition which practically never can be obtained in the hand-fired furnace. Inasmuch as the hand-fired furnace also represents definite limitations in the way of utilizing the cheapest grades of fuel, engineers are today finding that the way to improve boiler room operating conditions is to install mechanical stokers." From this point the bulletin takes up the dollars and cents value of mechanical stokers, dealing with each of the savings effected, in detail. It next deals with the application of advanced engineering principles and modern stoker design, and then concludes with a section on the service of the mechanical stoker, unique in its treatment. The bulletin is a beautiful example of the printer's and engraver's art, as well as being one of the most readable and interesting pieces of literature put out in the power equipment field. Complimentary copies will be forwarded to interested engineers and executives, upon request.

Herbert Morris, Inc., Buffalo, has published an illustrated folder in which worm-gear chain blocks are described and illustrated. One illustration shows a 10-ton block lifting a load of 15 tons, the lifting being done by means of its own gears.

A. W. Cadman Mfg. Company, Pittsburgh, has published a 16-page illustrated booklet in which bearing metals are described. The booklet contains interesting information including requirements of bearing metals, properties, tensile strength and bonding properties, etc.

Two bulletins under one cover are being circulated by the U. S. Galvanizing & Plating Equipment Corporation, New York, the first devoted to describing and illustrating moving cathode plating apparatus for plating or electric galvanizing, and the second to automatic cleaning, pickling, acid dip, neutralizing, rinsing, drying and allied equipment.

The Esterline-Angus Company, Indianapolis, is circulating a 4-page illustrated folder in which the use of graphic recording equipment is described. How engineers for the Milwaukee Coke & Gas Company maintained a continuous check on the performance of a gravity concrete mixing plant is told in the booklet as well as how graphic records taken in a Chicago office building showed why lighting bills were high.

The Thompson Electric Company, Cleveland, has published a 12-page illustrated folder in which disconnecting electric light hangers for use in industrial and other lighting, are described and illustrated. The booklet points out the waste caused through dirty reflectors as well as the dangers encountered by workmen in climbing to wash stationary lamps. With the aid of lamp hangers such dangers and waste can be eliminated. The lamps can be installed anywhere and easily lowered, in the latter operation the lamp disconnecting from the circuit leaving the wiring undisturbed. When pulled back into place again the lamp automatically goes back into the circuit and locks. A complete description of the hangers is given which is supplemented with illustrations and line drawings.

A power fed vertical hollow chisel mortiser is described and illustrated in a 4-page illustrated bulletin being circulated by the Oliver Machinery Company, Grand Rapids, Mich. This mortiser will handle chisels from ¼-inch to ¾-inch square. The stroke is adjustable from 2½ inches to 4 inches long. Stock 6 inches wide can be centered beneath the chisel. Hollow chisels with 4-inch blades will mortise in 12-inch high material; chisels with 2¾-inch blades are commonly used in ¼-inch and 5/16-inch sizes. The column is a rigid, hollow, box type, one piece casting having a wide flanged floor support. It encloses the power feed mechanism with the exception of the drive pulley. The ways for the chisel carriage and for the table are planed at one setting to insure accurate alignment. A fan blower built-in back of the column furnishes a constant air blast which cools the tools and keeps the work free from chips. A complete description of the tool is given.

The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., NOVEMBER, 1922 No. 11

American Iron and Steel Institute Meeting

Judge Gary Suggests Second Washington Peace Conference at Twenty-Second General Meeting—A Number of Extremely Valuable Technical Papers Were Read.

ON October 27 the American Iron and Steel Institute held its twenty-second semi-annual meeting in New York. The day was devoted to the address of the president of the Institute, Judge Elbert A. Gary, chairman of the United States Steel Corporation, and to the reading and discussion of technical papers, which are listed below. A number of these papers are included in this issue.

Address of the President, Elbert H. Gary, chairman, United States Steel Corporation, New York.

"Modern Methods of Mining Coal," H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

"The Storage of Bituminous Coal," H. H. Stoek, Professor of Mining Engineering, University of Illinois, Urbana, Ill. J. V. Freeman, Director, Coal and Coke Research Laboratory, United States Steel Corporation, Joliet, Ill.

"The Present Status of the Electric Furnace in Refining Iron and Steel," J. A. Mathews, President, Crucible Steel Company of America.

"Economic Importance of the Power Plant in the Steel Industry," E. F. Entwisle, Assistant General Manager, Steel Plant, Bethlehem Steel Corporation, Steelton, Pa.

"The Steel Requirements of the Automotive Industry," Henry Chandler, Metallurgist, C. H. Wills & Company, Marysville, Mich.

"Heating Furnaces for Blooms, Slabs and Billets," W. P. Chandler, Jr., Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

"Use of Liquid Fuel in Metallurgical Furnaces," R. C. Helm, Director, Worcester Research Laboratory of the American Steel & Wire Company, Worcester, Mass.

"The Thermal Efficiency of the Open Hearth Furnace," C. L. Kinney, Jr., Superintendent No. 1 Hearth Department, South Chicago Works, Illinois Steel Company, South Chicago, Il. G. R. McDermott, Fuel Engineer, South Chicago Works, Illinois Steel Company, South Chicago, Ill.

"Fluor Spar and Its Uses," G. H. Jones, President, Hillside Fluor Spar Mines, Chicago, Ill.

Gary Suggests Nations' Meet.

Another international peace conference in Washington for the full and frank discussion of all unsettled financial, commercial and industrial questions in which the United States is interested, was suggested by Elbert H. Gary, chairman of the United States Steel Corporation in a speech at the semi-annual meeting of the American Iron and Steel Institute, of which he is president. Such a conference, he said, should be participated in by able, open-minded, well-disposed representatives from the different nations, such as those who appeared at the recent limitation of armament conference.

"If there be such a meeting," he declared, "and the delegates are all of the type referred to, there will result incalculable good to all who are parties. They would not decide how to overcome the old established law of supply and demand, how to avoid or repudiate existing obligations, but rather how and when to fulfill them without irreparable injury to anyone or the sacrifice of principle. While it is true members of such a conference would be compelled to consider and in a large measure be governed by the wishes of their respective constituencies, it is believed the large majority of the populations making up such constituencies would be sensible and honest."

Should Pay War Debts.

Cancellation of Europe's war debts to the United States was opposed by the speaker. The debts, he said, were voluntarily, openly and fairly contracted and cannot be cancelled or disposed of on any other basis, without doing damage to justice and rules of propriety

"To cancel these debts or any part of them without full payment," he asserted, "would be forced charity, and that is never agreeable to the donor, and, as a rule, equally disagreeable to a self-respecting person or nation. It is the individual citizens of the different countries who are to be consulted and whose decisions must control.

"Americans generally would not be content with governmental action which relieved from debt the citizens of a foreign nation by increasing the burdens of the former. Likewise foreigners generally would oppose any enforced act of charity. Certainly it would be abhorrent to the business man and woman of both countries."

The attitude and conduct of a nation, he said, should not be different from that of an individual.

Thinks Nations Can Pay.

"In the judgment of many of us the foreign nations can and are willing to pay their debts, some sooner than others, and most of them sooner than is now generally admitted. We know something of their capacity to work and earn and save and their successes in business and their mode of living. No doubt in many instances productive capacity has been reduced and we share in their suffering on account of deprivation.

"We should be cheerfully willing to extend payment at reasonably low rates of interest. We should be glad to make new loans whenever we are confident they will be paid, and thus assist in restoration and rehabilitation. Every man or nation, in order to measure up to obligations, must work and save, must be prudent and economical."

Settlement on both sides of industrial disputes or questions involving the welfare of the pubic was advocated by the speaker.

There are no obstacles to continued prosperity in the iron and steel business in the United States, the speaker asserted, except such as may arise from interference with the natural course of supply and demand. Touching on the recent coal and rail strikes, he said if the natural course of business had not been interfered with the iron and steel industry would now be enjoying success and prosperity greater than ever before, so far as volume is concerned. The one to blame, he said, is "any one who by word or deed has interrupted or hindered the operation of the natural laws of supply and demand; or has interfered with the full, free and unlimited right to work, to operate, and to produce."

Present Status of the Electric Furnace[*]

Brief History of Development of Electric Furnace for Refining Iron and Steel—Reasons for Expansion of Electric Steel Making—Demand for Clean, Sound Steel Will Cause Its Increased Use.

By JOHN A. MATHEWS[†]

It seems to have been generally overlooked by the steel trade that this year, 1922, marks the ter-centenary of iron making in the Western Hemisphere. In 1622, the first iron was made at Falling Creek, Va., and in the same year the plant was destroyed and the workmen massacred by the Indians. It is a far cry from charcoal hearths and forges to the consideration of the electric furnace—the latest development in steel making processes.

The earliest literature of electric melting of iron and steel dates back but a score of years and was provided by the inventors of various furnace types. It is characterized by the enthusiastic optimism of the inventor and on that account may not have been considered very seriously by conservative, practical steel men. Their confidence in electric furnaces may not have been greatly increased during the next few years by the writings (including my own) of those who made the earliest installations. They may have felt that there was something of the child-with-a-new-toy air about them, and that both inventors and early users were overstating the case and that time and further experience might change matters. The war needs stirred some of the doubting Thomases to action and furnaces were installed in great numbers, particularly in the years 1917 and 1918. So rapid was the introduction of electric furnaces at this time that I felt constrained to utter a word of caution in a previous paper to this Institute[‡] when I said: "We will pass through a period of reaction and dissatisfaction with electric products while many of the new furnaces are in the experimental stage."

This opinion was based upon the fear that furnaces could be built faster than skilled operators could be trained. I now feel that my fears were justified by the experiences of the war period, for much electric furnace product was not what it should have been, and possibly not as good as much of the open hearth product produced during the same period. I have always discouraged the idea that the electric furnace was a foolproof and automatic process for making superior steel by those unskilled in steel making.

I believe now that the period of disaffection is past and that the 16 years of experience, since the first electric furnace was installed in America, at the Halcomb Steel Company, have been sufficient to afford a sounder basis of judgment than may have been afforded by the earlier literature already mentioned. There are now nearly 1,000 electric furnaces in America and Europe, not quite one-half of them in the United States and Canada. Constant interest in these developments from the beginning leads me to feel that the pioneer writers were not over enthusiastic and that their claims and predictions have, in general, been fulfilled.

It will surprise many of you to know that Italy has about 180 electric furnaces for steel melting, that 27 of them are from 15 to 25 tons capacity, and in 1921 her tonnage of electric steel was second only to that of the United States, and reached a new high mark for that country. The annual productive capacity there is about 1,000,000 tons, and Doctor Giolitti recently told me that some of these furnaces were operating at unusually high speed and with great economy of electrode consumption, as low as 6½ pounds per ton for cold melting. For installed capacity, Italy ranks ahead of Germany, England

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[*] A paper read before the American Iron and Steel Institute, at New York, October 27, 1922. The paper was entitled, "The Present Status of the Electric Furnace in Refining Iron and Steel."

[†] President, Crucible Steel Company of America, New York.

[‡] "The Electric Furnace in Steel Manufacture," Yearbook, American Iron and Steel Institute, 1916, p. 73 (May, 1916).

and France, and second only to the United States.

The rapidity with which electric furnaces have been installed within the last decade all over the world calls for some analysis as to cause. After 10 or 12 years of invention and pioneering there were about 125 furnaces in the world in 1912. At this time, Germany led with nearly one-third of the total number. Today, as nearly as may be estimated, there are 1,000 furnaces, 388 of them being in the United States, according to the *Iron Age* figures for January 1, 1922. Accurate statistics have been extremely difficult to secure during late years, but according to Doctor Richard Amberg* there are 65 furnaces in Germany engaged in the manufacture of ingots, with a yearly productive capacity of 430,000 tons and an unknown number of furnaces making steel castings with a capacity estimated at 300,000 tons per annum. I think we may estimate the total number of electric furnaces in Germany as about 100 to 110.

The reasons for the world-wide expansion of electric steel making are three:

(1) Cheapening of wholesale power rates, due to hydro-electric and improved steam plant developments. Thus it is now commercial to use electricity for melting, whereas the original promoters of arc furnaces felt that their use would be of necessity confined to refining of metal premelted by the older processes.

(2) The extreme flexibility and adaptability of electric furnaces to a wide range of uses. It has been shown by experience that they may be successfully used for melting cold charges or refining liquid charges, for making ingots or castings, and for melting ferro-alloys. They may be used in conjunction with the blast furnace or cupola for making grey-iron, malleable and semi-steel castings. For foundry use particularly, the small units are advantageous for making frequent small heats of steel or iron castings.

The most popular size of electric furnace in this country is of six gross tons capacity, but furnaces from one-half ton to 40 tons capacity have proven equally successful. In furnaces of six tons, or a little larger, hand charging is general, but in the larger sizes either mechanical charging of cold materials or the use of hot metal charges is usual. Duplexing of open hearth steel is practiced in many of the larger units, while triplexing is done at the great installation at the Illinois Steel Company as described at the Institute a few years ago by Mr. T. W. Robinson†.

All of the manifold methods of operation are possible with the use of arc furnaces, which are by far the most frequently used, here and abroad. Of the different types of arc furnaces in the United States nearly one-half are of the Heroult type and considerably more than one-half of the productive capacity is represented by them.

The electric furnace has small possibilities in this country for the manufacture of pig iron from the ore, but during the war period several furnaces were used to make so-called synthetic pig iron from turnings and borings and other light scrap, in the United States, Canada and France. In Sweden, Norway and Italy, where metallurgical fuel is very dear and electricity is cheap, electric smelting of ores is an established industry. The world's production for 1921 is placed at 377,900 tons, and most of you will recall that the year 1921 was not a good year for high records.

(3) Quality of products. A new process to succeed must be cheaper in operation or produce a better quality. The cost of electric steel is rarely lower than open hearth and never lower than Bessemer and therefore its success is presumably due to its producing a generally superior product. Of course, there are especially favored localities or peculiar market conditions which warrant the installation of small electric furnaces where open hearth and Bessemer installations would be out of the question. In the same localities and markets electric furnaces do operate successfully alongside of large tonnage plants and under such conditions quality must be the principal reason for success rather than low cost.

It is quite obvious that this country has not installed 1,500,000 tons of productive capacity to compete with the present crucible capacity of one-tenth that volume. In an address several years ago, I said, "It is seldom that a process is discovered that cannot be improved upon. Crucible steel is an exception to this rule. This earliest process makes the best steel and has never been surpassed." The superior lasting qualities of German guns was often ascribed to the use of molybdenum, zirconium, uranium or other strange alloys, but my own idea is that the use of clean, well melted crucible or electric steel is a more probable explanation. Crucible steel was employed for many submarine crankshafts, and apparently the Germans recognize that when fabricating and machining costs are far in excess of material cost, and where dependability is a vital necessity, it is a poor policy to save at the spigot and let out at the bunghole. Quality depends upon the selection of raw materials, the process of melting and subsequent care in forging and heat treating. The electric furnace provides a reducing atmosphere in which sulphur is readily removed and with it goes one of the generally recognized inclusions, manganese sulphide, and the same condition serves to eliminate oxides.

The electric furnace, therefore, is a potential source of clean steel which is more highly appreciated than formerly, and the electric product is opportune to meet the new and exacting requirements for ordnance, automobiles and aeroplanes, and other devices in which alternating stresses are very severe. The importance of clean steel has been observed in the course of extensive investigations of the fatigue of metals under the direction of Professor H. F. Moore. It is not too much to expect that the higher the elastic or proportional limit resulting from heat treatment, the more serious would become defects such as non-metallic inclusions and seams in parts made from inferior steel. Doctor McCrance confirms this in stating that fatigue failure under repeated stress is a progressive failure, starting in all cases in some defect or irregularity either of internal structure or external surface.

By way of illustrating the freedom from inclusions in electric steel, I might mention the result of actual count of hairlines, due to inclusions, in the ground surface of steels of the same chemical specification—a chrome-nickel steel for aeroplane crankshafts. As the result of tests on several heats of this steel by the basic, and acid open hearth and basic electric process, the average count ran in the ratio of 8 to 4 to 1, and the hairlines in the electric steel were much shorter than in the steel of open hearth manufacture. Another illustration from my own experience may be convincing. In one of the races at the Indianapolis Speedway a few years ago, about one-half of the cars starting did not finish because of failure of vital parts. The following year nine or ten cars, which

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*Electric Furnaces in the Iron and Steel Industry, Helios, vol. 28, p. 169, for April, 1922.

†"The Triplex Process of Producing Electric Steel at South Chicago," Yearbook, American Iron and Steel Institute, 1918, p. 115.

I knew contained our electric furnace product in their important parts, all finished the race without mishap, and included the winning car. A practical demonstration of this kind is more eloquent than columns of figures of laboratory tests. The recent paper by W. J. Priestley* outlines the splendid results of electric furnace ordnance steels made at Charleston, W. Va., in the largest furnaces in the United States. He shows that the results are due to clean steel and freedom from oxides, sulphur and phosphorus. These results show that large units, with proper handling, can produce very high quality steel, and we see no reason, now that larger electrodes can be made of dependable quality, why a 60 or 80-ton furnace cannot be expected to give relatively as satisfactory results. The electric steel rail is still a desired possibility. The increased demands made upon materials of construction call for new methods for meeting those demands. As I stated here six years ago, the electric furnace was opportunely invented to meet a new demand rather than to replace an old process.

It would be mere repetition to restate here the various types of furnaces, such as arc, induction, radiation, etc. They have been described in books and technical magazines and we need only observe in passing that there have been no new principles of heating employed since the first few years—with the possible exception of Doctor Northrup's high frequency induction furnace which has not thus far been successfully employed in units of commercial size in the steel industry. Of mechanical and electrical refinements there have been many, all in the nature of improvements in regulation and economy. Among these may be mentioned two of American origin, J. A. Seede's automatic electrode regulator, and E. T. Moore's peak-load regulator. The principle of dual, or rather multiple, voltages was embodied in our orginial installation in 1906, but its metallurgical significance was not so apparent as it was later when we installed a process employing a 220-volt arc and with considerable difficulty succeeded in persuading the inventor that provision for a lower voltage for use during the refining period must be provided. The desirability of relatively high voltage for melting and low voltage for refining is now generally recognized. Many improvements have been made as the shortcomings of the earlier furnaces appeared, such as well fitting doors, water cooled arches, better electrodes and holders and economizers to cut down oxidation and waste of the electrode. In my own experience I have seen electrode costs per ton of product as high as $8.00 gradually decline to 35 cents. This was in a furnace refining molten charges.

The electric furnace is also a recognized factor in melting non-ferrous alloys such as "Nichrome," "Rezistal," "Stellite," stainless steel, manganese steel and high-speed steels, besides an endless variety of the simpler alloy and carbon steels from the mildest to the hardest tempers. As stated earlier in this paper, its astonishing flexibility—versatility, we might call it—has attracted the attention of the metallurgical world in almost every branch of smelting, melting, refining, heating and even baking metals. To those of us who have watched its growth from the start, it seemed very slow in achieving the recognition we felt must inevitably come to it, but at last our early confidence has been confirmed in every steel-making country, because its products have fulfilled almost every expectation in every field wherein it has been thoroughly tried. The present success is due not only to the original inventors of the basic processes, but also to the active co-operation of the great manufacturers of electrical equipment, furnace designers and builders, makers of refractories and electrodes and a group of earnest metallurgists in many individual plants who have studied every detail of operation.

When users acquire a full appreciation of what clean, sound steel means in terms of national efficiency, safety and economy we shall see more rapid growth that has as yet been seen. Its usefulness to engineering and industry has just begun.

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*"Effect of Sulphur and Oxides in Ordnance Steel," Transactions American Institute of Mining and Metallurgical Engineers, vol. lxvii, p. 317 (1922).

The Steel Requirements of the Automotive Industry*

Steels Suited to Process of Fabrication, Service Conditions and Major Automotive Parts—Tests to Determine Mechanical Properties—Reduction in Area an Indication of Qualitative Importance

By HENRY CHANDLER†

PRIMARILY, the physical properties of automotive steels determine which of those steels are best adapted and most essential to the automotive industry. Speaking generally, the mechanical characteristics of materials determine, first, the thing we are able to make, and second, the methods we are to employ in making it. The discovery of each new material is invariably followed quickly by the development of many new devices to adapt this new material to man's use. Conversely, the removal from the market of any of our common materials, such as copper or rubber, would result in a far-reaching industrial readjustment.

The more highly specialized an industry becomes in its development, the greater is that industry's dependence upon the properties of the metals peculiar to it. Our first thoughts in the development of a mechanical idea are governed by and limited to the materials then available. Later, competition and a fuller understanding of our actual needs result in the discovery of materials still more suitable. For instance, in the early pioneer days of the motor car industry, crankshafts were made from billets intended for rails, gears from tool steel, cylinders from iron suitable for stoves, and, similarly, all other parts were made of the only materials then available.

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*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†Metallurgist, C. H. Wills & Company, Marysville, Mich.

Such practice would now be not only impractical, but actually impossible. Today we rely upon specialized automotive steels for our major parts. The automotive manufacturer is now buying physical properties. The chemical specifications, from which steels are actually purchased, are not of importance in themselves but only for the physical characteristics which they define. It is the mechanical characteristics of the steels that are of prime importance to the manufacturer, both in the design of his product and in the mechanical methods he is to employ in manufacturing it. These are the two factors that determine his commercial success.

It will be necessary in this report to generalize. It is manifestly impossible to treat the numerous parts of a motor car individually. The steels now used by the automotive industry, their treatment and characteristics, can be found amply described in the specifications of the Society of Automotive Engineers and other organizations. Detailed application of these specifications to a given part or group of parts is impractical without a thorough knowledge of the conditions demanded and can be of only individual interest. We will, therefore, only attempt to determine which of the many steels now used by the automobile builder are characteristically "automotive steels" and the general properties such steels must possess, in terms of the tests usually applied to them.

The adoption of a steel for commercial purposes is predicted upon two general questions; first, "How will this steel adapt itself to the necessary manufacturing processes?" and second, "Will the part, when made of this steel, withstand the forces, such as wear, breakage, etc., that operate for its destruction?" The answer to these questions is obtained through a survey of the mechanical characteristics of the metal. This twofold importance of the physical properties suggests a natural division of the various parts of motor cars.

Steels Suited to Process of Fabrication.

Our first group will contain all those automotive parts which are made from steels in which the physical properties, that control the processes of fabrication, are of first importance.

This group includes most of our sheet metal parts, low stressed bolts, nuts and other screw machine products, as well as miscellaneous forgings, hardware and stampings. Such parts, due to design, when made from almost any material which will commercially meet the manufacturing requirements, are amply strong and tough to withstand all normal service conditions. Our specifications for this group are directed to simplify fabrication.

These requirements are easily and quickly ascertained. As a matter of fact, actual use becomes the best criterion and we are able to define our steels in terms of how they must behave in the shop. Our deep-drawing stock must draw deeply. Our screw machine stock must machine readily. Our forging bars must be free from defects and respond readily to forge and machine shop operations. Uniformity of quality is as important as degree of quality.

In general, requirements of this nature are not peculiar to the automotive industry. They are common to all industries where steel is similarly fabricated and such steels are "automotive steels" for the single reason that large quantities of them are consumed by the automotive industry.

In particular cases, however, the manufacture of certain individual parts of this group has been developed into separate specialized industries and we here find a corresponding development of individual steels of this class into special steels. This has been the case particularly with frames, fenders, cold-headed bolts, disc wheels, bodies, etc. Each of these presents its individual problems and each requires its individual steel specifications, specialized proportionally to the refinements in manufacture and design which have been developed by the individual manufacturer.

Chemically expressed, the needs of this group are amply met by the standard grades of carbon steels now manufactured.

Steels Suitable for Service Conditions.

The second group contains those special automotive parts which are made from steels in which the physical properties demanded by service conditions are unusual and of first importance. Steels for such parts, due to the peculiar conditions of service to which they are subjected, must have individual physical properties developed to an unusual degree. The mere ease of manufacture is of secondary importance and is considered only after the service requirements are amply met. Valves, ball bearings, magnets, armatures, hardened keys and the like are all typical of this class.

For example, in valves, strength, hardness and toughness must be maintained at high temperatures and the metal must withstand the corrosive and erosive effects of the products of combustion. To meet these particular requirements, many special steels have been developed, such as high-tungsten, silicon-chromium, cobalt-chromium and others, each with its own peculiar advantages for this service, and each with its own distinct engineering following. It was only after long, intensive development of materials that ball bearings became possible for motor car use. Also the electrical properties now attained in armature and magnet steels are evidence of the specialized nature of these parts.

Naturally, then, this group requires special analyses. The manufacture of these parts or of the steels suitable for them can be commercially undertaken only after a thorough understanding of the complex problems involved. Adequate treatment of this specialized group is manifestly not within the scope of this paper.

Steel for Major Automotive Parts.

The third group, and that one with which we are chiefly concerned, contains most of our major steel parts. The front axle and its various component units; our power train from piston pin, through connecting rods, crankshaft, transmission, universal joint, to the rear axles; springs; heavy duty gears; and, in general, all parts subjected to live loads of a high order are included in this division.

These parts are uniquely automotive parts, that is, the forces of wear, fatigue and breakage to which they are subjected; the processes by which they are fabricated; and the economic factors which limit their cost, are peculiar to and characteristic of the automotive industry alone.

The steels for these particular parts may, therefore, be truly called "automotive steels." Their development into the many standard grades of alloy steels has been coincident with and in a large measure responsible for the development of the motor car.

Parts in this group, in operation, are subjected to much punishment. Wear, shock, vibration, torsion and other complex application of forces all tend to destroy their usefulness. Our steels must resist all these and at the same time readily and economically adapt themselves to the numerous processes of forging, heat treatment and machining, incidental to the production of these parts. The quality of our part cannot be separated from the cost of our part.

Tests Used to Determine Mechanical Properties.

How then are the mechanical characteristics necessary to fulfill these conditions determined?

The automotive manufacturer relies upon two types of test; first, that of actual use itself, and second, comparatively simple and rapid laboratory tests, whose indications he has learned to correlate with the results of actual use.

The test of actual use, while undoubtedly our final criterion, nevertheless has serious disadvantages. It is generally slow and its results are difficult to express in terms usable in steel specifications. We cannot, for instance, describe our steel to the producer by stating that it must be the best and cheapest for our crankshafts, gears or other parts. We must have a means of measuring these requirements; some common method of defining the degree of hardness, strength, or other desired property. Therefore, laboratory tests, whose results may be numerically expressed, have been devised to furnish us with information as to the likely behavior of the metal in service. Such tests, in general, consist in measuring comparatively definite physical quantities by simple experiments which may be rapidly carried out and whose results may be easily checked.

It is not yet easy to say which and how many of the various physical properties, which metals possess, are of direct importance in the construction of these automotive parts. The conditions under which a motor car must operate are unusual. Long, hard, uphill or sandy pulls, shocks from rought and choppy roads, brakes suddenly applied, continued high speed, all these subject the mechanism to stresses and strains, and combinations of destructive forces, the results of which are difficult if not impossible to calculate. It is not a question of resistance to simple static stresses, but of the ability of the parts to withstand dynamic forces or the work done by these forces. The phenomena embraced in the terms fatigue, vibration and shock become important.

Dynamic tests, designed to isolate and measure the physical properties which determine the behavior of steel under these conditions, have been suggested. However, the great complexity of the various facts which determine the results of such tests and the little understood influences of slight changes in test conditions have limited their use, with but few exceptions, to qualitative rather than quantitative results.

Of the many properties easily measured, the automotive manufacturer depends chiefly upon those obtained by the following tests:

First, the tensile test.

Second, the Brinell and scleroscope hardness tests.

Third, an impact test (in this country generally the Izod).

Fourth, thermal and metallographic investigation.

These tests, while not conclusive, nevertheless, when properly interpreted and supplemented by close observation of actual service, sufficiently define our steels for commercial purposes. Therefore, we will confine our discussion to the characteristics of these steels as disclosed by the above simple tests.

Chief reliance is placed in the tensile test. It will be readily admitted that the use of some sort of a dynamic test, which would more closely approximate the conditions of automotive service, would be more justified. Nevertheless, the permanence of the tension test and the general acceptance of its data by both steel producers and steel consumers, lead us to anticipate that its results, when supplemented with other information, will within limits tell us much of the probable dynamic character of the steel.

Briefly, the tension test is this: A bar of steel, of known dimensions, is subjected to a tensile load. This load is increased gradually, until rupture of the steel occurs. The maximum force so withstood by the bar is recorded as the ultimate tensile strength. The smallest load necessary to produce permanent set in the bar is designated as the elastic limit. Both of these are calculated on the basis of one square inch section. The percentage of increase in length and the change in cross section, due to the flow of the metal at the point of fracture, are also measured and calculated. The former of these is called the percentage of elongation and the latter, the percentage reduction in area.

Obviously, such a test does not duplicate the conditions to which the steel is subjected in actual motoring service. Its real value lies in our ability to correlate the data so furnished with the results of our other tests and the results of actual engineering experience. Tensile strength, elastic limit, reduction in area and elongation, these simple properties, when taken individually, convey little: but collectively, and with proper emphasis on their relation to each other, they form a sound basis for estimation of quality.

Motor car parts are with few exceptions of great enough size and mass to withstand many times the static load which they are called upon to bear. As a matter of actual practice, it is the ability to take punishment, such as shock, vibration, impact and the wear and tear of the roads, that we require of our materials; and it is the ability of a unit mass of steel to withstand work done upon it that we try to determine.

Remembering, then, that the physical properties, made evident by the tensile test, are properties of a test bar and are only indirectly properties of the steel tested, let us examine the results of this test in terms of the work actually done and the metal actually affected.

During the breaking of the bar, we are doing work; that is, we have measured variable force starting at the elastic limit, gradually increasing up to the ultimate strength and then decreasing to the breaking load, which moves in all a distance equal to the total elongation of the bar. Since both the force applied and the distance through which it moves are known, the work done is easily calculated.

The actual amount of the material in the bar, the usefulness of which is practically destroyed by this work, is more difficult to determine. Our reduction in area, however, gives us an indication of this quantity. When we examine the test bar after the test, it will be found that the metal directly back of the fracture is still able to withstand a slight amount of work; still farther back, more work; and so on until metal but slightly affected is reached. The reduction of area describes and is a rough measure of the degree of this condition. It is of more importance qualitatively than quantitatively.

Consider for a moment the following illustrations. Fig. 1 represents a fractured tensile bar of a material of low reduction in area, as characterized in certain bronzes. Fig. 2, a similar bar of material such as an alloy steel, showing high reduction in area. Let us, for the sake of argument, assume that the mean breaking strength and percentage of elongation were in each case identical. Thus, with no further evidence to go by, it would be assumed that the materials were equally strong and tough and equally suitable for our motor car part.

It will be observed, however, that there is a marked difference in the appearance of the two test pieces. The steel bar shows a marked necking down at the point of fracture, due to the local flow of metal between the lines "A"—"B" while the bronze bar has stretched almost uniformly throughout its entire length. Hence, although the same amount of work was performed in rupturing both test pieces, it can be readily seen that the mass of metal affected in the bronze was considerably greater than that in the steel. Consequently, the resistance of a unit mass of the material of bar No. 2 was greater and the reduction in area is a measure of this fact. The higher the reduction in area, other conditions being equal, the greater the ability of a unit mass of the steel to withstand work done upon it .

The tensile test may therefore be considered as a dynamic test where work is done at a slow rate. Its results, as a measure of work done and metal affected, while not numerically exact, are at least proportional to them. This relationship might, roughtly, be expressed as follows: Quality of metal as evidenced by the tensile test is equal to

$$\frac{\text{Work Done}}{\text{Metal Affected}}$$

which is proportional to

$$\frac{\text{Mean Breaking Strength} \times \text{Elongation}}{\text{K—Reduction in Area}}$$

where "K" is a constant, the value of which varies with the type of fracture, and the mean breaking strength is the average force applied to the bar after the elastic limit has been passed.

It is common practice, as a check, to supplement the tensile test with an impact test in which a notched test bar is broken at a rapid rate by a falling hammer. The Izod test, in this country, enjoys the most widespread use. The work done is recorded directly in foot pounds and the mass of metal so affected, due to the mechanical effect of the notch, is in each piece fairly constant.

Our hardness test, as determined by the Brinell and sceleroscope, is used as a check on our heat treatment processes and as an index to machineability and resistance to wear. The results are purely empirical and of value only when coupled with the observations of experience.

Difficulties will immediately arise if we endeavor to apply too literally the results of any of these tests to conditions greatly different from our test conditions. Other considerations based upon the metallographical makeup of the steel, may greatly change these results under the conditions of actual service. Steels, as a class, are composed of a mixture of crystalline and amorphous materials. The relative sizes, proportions, distribution and qualities of these constituents, play an all important part in the behavior of the steel, under various applications of forces. Metallographical and chemical investigation are doing much to determine this relationship between microstructure and physical properties. However, in uniform materials, uniformly heat treated, these conditions are fairly constant, and except in special cases to determine soundness, metallographical investigation is largely confined to pure research.

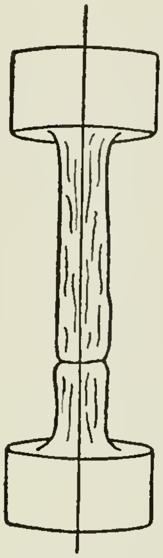

Fig. 1.

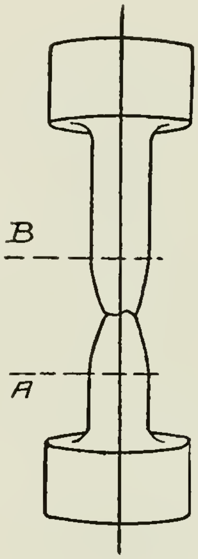

Fig. 2.

Effects of Heat Treatment.

Steels for the parts now under discussion are invariably used in the heat treated state. The behavior of the steel under thermal treatment also bears a relation to its dynamic characteristics.

When a piece of steel is heated beyond its critical point, it undergoes a chemical and physical transformation. If thereafter it be slowly cooled, this transformation reverses itself and the material returns to its normal state. However, when the steel is quenched, the physical and chemical changes which took place during the heating have now no opportunity to reverse and the material, when cool, is consequently in a state of unstable equilibrium. This degree of instability is measured by the temperature to which we can subsequently reheat or "draw" the steel after quenching and still maintain our requisite strength. In other words, the higher the drawing temperature that the steel can withstand, the greater is its molecular stability and the greater is its resistance to any subsequent molecular change, whether the latter be produced mechanically or otherwise.

Other factors being equal, the steel with the highest drawing temperature will be the most satisfactory for those automotive parts that require resistance to "fatigue."

But here again caution must be exercised lest our conclusions carry us beyond a logical point, because the metallographical size, nature and distribution of the constituents of the steel are also factors to be reckoned with.

We have indicated in the preceding paragraphs that the merit of a steel for motor car use was closely related to the results of the tension test; and that this relationship might be expressed by the proportion:

$$\frac{\text{Mean Breaking Strength x Elongation}}{\text{K—Reduction in Area}}$$

It is perfectly obvious that such a simple proportion as the above can in no way be an exact statement of the really complex relation which exists between the phenomena occurring in the tensile test and the exceedingly complex combinations of properties required for our various parts. Nevertheless, since this test so greatly influences the automotive manufacturer, in his choice of steels, we are justified in considering what further information it can supply us with.

The physical properties of our steels are direct functions of the drawing temperature. Thus the elastic limit, elongation and reduction in area may all be varied over wide limits by heat treatment.

It therefore follows that our merit number, as previously computed, will also change in value according to changes in the drawing temperature and will in a given steel reach a maximum at some definite temperature.

For example, a hardened but not drawn bar of high carbon steel may show an elastic limit of say 175,000 pounds per square inch. Nevertheless, it can be readily seen by breaking the bar with a hand hammer that this strength of little use for the parts under discussion. Due to the slight elongation and reduction in area possessed by the bar, these factors in our equation will be small and our merit number will be very low, in spite of the relatively high elastic limit. If we now reheat or draw the bar, we find that although of less strength as measured by elastic limit, it will easily withstand our efforts with the hand hammer. A further increase in temperature still further increases the amount of energy which must be expended before breakage occurs, until a maximum point is reached where the decrease in tensile strength and elastic limit is not compensated for by the corresponding increase in elongation and reduction in area. Further elevation of the drawing temperature beyond this point results in a decrease in merit until the critical point is reached, with its accompanying fundamental changes in qualities. This drawing temperature at which maximum merit occurs is different in different types of steel and is fairly independent of the carbon content. This consideration is important in comparing the suitability of the various steels for different uses and in defining our practice in allotting a particular analysis of any given type of steel to a particular part.

Thus we find that the steels in which this temperature of maximum merit is naturally low are used exclusively in the condition resulting from low drawing temperatures. This is the case with silico-nickel steels which are widely used for hard light armor plate.

Our most widely used spring steel is of an analysis which develops the necessary spring requirements of strngth, etc., at a drawing temperature but 60 deg. removed from the temperature of maximum merit for that steel.

It is common practice in the manufacture of large carbon steel forgings to meet the elastic limit requirements in so far as possible by carbon additions and thus maintain a high drawing temperature. Since there is, then, a definite drawing temperature, at which the dynamic properties required in automotive steels are developed to their maximum, for each particular steel analysis, there is, consequently, a corresponding definite elastic limit at which the particular steel may best be used.

Most of our major automotive parts require, owing to the limitations imposed by design, minimum strengths of a relatively high order. Also the successful operation of these parts, under the difficult service conditions, pre-supposes the development of the merit index to a high degree.

Alloy Steels Necessary for Certain Parts.

Carbon steels may develop under suitable heat treatment elastic limits which are sufficient for most of these parts, but their use is promptly excluded where the requirements exceed 80,000 pounds per square inch, and even for requirements under this figure the merit index is of a lower order than is desired.

Accordingly, our automotive alloy steels have been developed, which not only will show higher elastic limits than those obtained in carbon steels, but also for any given elastic limit, demanded by design, will exhibit resistance to fatigue, vibration, shock and wear, far greater than that of any carbon steel.

This development has been coincident with and in a large measure responsible for the development of the automotive industry.

The commercial factors, as defined by the adaptability of these materials to the various mill processes of manufacture and the subsequent operations of fabrication such as machineability and general adaptability to shop conditions, have in a like manner been improved until it may now be fairly said that through the use of alloy steels, the automotive manufacturer can build a better product at a cheaper price.

BLAST FURNACE HEARTH GAS ANALYSES

In the analytical work on blast furnace hearth gases, being performed by the United States Bureau of Mines, the composition of the gases in the tuyere plane has been determined at two furnaces in the Pittsburgh district. One, a furnace making ferro-manganese, showed conditions practically identical with Southern practice on basic or pig iron. The other, making basic iron, showed penetration of oxygen to a further distance than obtained in the Southern furnaces. Arrangements have been made with a blast furnace operation at Youngstown, Ohio, to obtain samples at other planes up the bosh. It is hoped that this work may bring forth some valuable information.

HEAT TREATMENT OF NON-FERROUS ALLOYS

At the Pittsburgh, Pa., experiment station of the Bureau of Mines heat-treatment experiments, including quenching and annealing, have been conducted on a number of cast non-ferrous alloys.

Use of Liquid Fuel in Metallurgical Furnaces*

Success in Using This Type of Fuel Depends on Furnace Design, Proper Methods for Its Distribution to the Furnace, and on Burners Which Will Atomize the Fuel So Thermal Value Is Utilized.

By R. C. HELM†

WITH the variations in economic conditions which have existed in different localities in the past few years, as regards the status of coal converted into condenser gas for use in metallurgical furnaces, an added impetus has been given to the study of the proper application of various types of liquid fuels where such fuels were available at prices which would permit of their economic use. Tar and fuel oil are the most common of the liquid fuels which are economically available for use in metallurgical furnaces and this paper has, therefore, been confined to their use only.

The use of oil as a fuel in furnaces for metallurgical purposes dates back a good many years, and the demand for it is constantly increasing. Originally, the oil was used in its crude form without the removal of any of the more volatile hydrocarbons. Naturally, the low flash point of such oils made them unsafe to handle. Moreover, the development of wider uses for these lighter oils demanded their extraction from the crude. The removal of these lighter hydrocarbons raised the flash point of the residue considerably, giving a resultant product which could be used with more safety. A large proportion of the oil now used as fuel is obtained as a residue in this manner, although some residues are so viscous and of such poor quality as to make them unsuitable for economic use. Other types of fuel oil developed from more complete refining operations are also adaptable for fuel purposes in metallurgical furnaces.

The calorific value of the fuel oils in common use varies from about 141,800 to 152,400 Btu. per gallon with corresponding density as measured by the Beaume hydrometer of 30 deg. to 12 deg. at a temperature of 60 deg. F. As oil is purchased by the gallon, the heavier but more viscous fuel oils, therefore, have the higher thermal values. The thermal value of the oil, however, does not necessarily indicate its adaptability for furnace use, as other features such as the content of impurities and size of furnace installation must be taken into consideration in deciding whether the heavy and more viscous oils should be used in preference to the lighter and more fluid oils.

Specifications under which fuel oils are purchased, usually require that the fuel oil shall not contain over one per cent of water and foreign matter, which are likely to interfere with the use of the oil due to clogging of burners and interference with the operation of valves. It is commonly agreed that the flash point should not be less than 150 deg F. (closed cup) as a matter of safety, although oils with a lower flash point are being used. Specifications for viscosity will vary dependent on the arrangement of the system used for conveying the oil from storage to the burner. The sulphur content of fuel oil, which may run as high as 4.0 per cent in some oils, is of great importance when used in connection with very high temperatures, such as are obtained in open-hearth practice, where the products of combustion come into direct contact with the charge during the melting down period. Under these circumstances, the percentages of sulphur may have to be limited in specification to 0.75 per cent or less depending on the open-hearth practice used. However, in certain localities, the less cost of high sulphur fuel oils as compared with low sulphur fuel oils has led to the development of an open-hearth practice whereby limited percentages of high sulphur oils can be used without detrimental effect to the finished product. With such a practice, specifications may be more liberal with respect to limiting the percentage of sulphur allowed in the fuel oil.

The introduction of the by-product coke plant increased the available amount of coal tar to such an extent as to result in making coal tar available as a liquid fuel for use in metallurgical furnaces. In addition to tar, the by-product coke plant also furnished a supply of gas for the same purpose. The usual proximity of the by-product coke oven plant to the open-hearth plant supplies a very good opportunity of utilizing both coke oven gas and tar as open-hearth fuel to the economic benefit of both plants.

As the production of tar goes hand in hand with the production of gas, the natural development of the use of both these fuels has resulted in the practice of using them in combination as fuel for the open-hearth furnace. The use of coal tar only has also been advantageously developed. As tar can be burned more advantageously where high temperatures are required, its use in steel plants has been chiefly confined to open-hearth practice.

Tar has a thermal capacity of about 155,000 to 162,000 Btu. per gallon. Coke oven gas as used is debenzolated and has a thermal capacity averaging 540 Btu. per cubic foot.

Many types of furnaces for metallurgical use have been equipped for use of liquid fuels. As far as the supply of air for combustion with liquid fuel is concerned, these types may be classified into three groups: (1) non-preheating furnaces in which the air is admitted to the combustion chamber at atmospheric temperatures; (2) regenerative furnaces operating on the reversing principle in which the air is preheated in a checker chamber before entering the combustion chamber, the checker chamber deriving its heat from the waste gases; and (3) recuperative furnaces in which the air for combustion is preheated by passing through a set of flues which alternate with flues through which the hot waste gases flow in a counter direction or at right angles to the direction of flow of the air.

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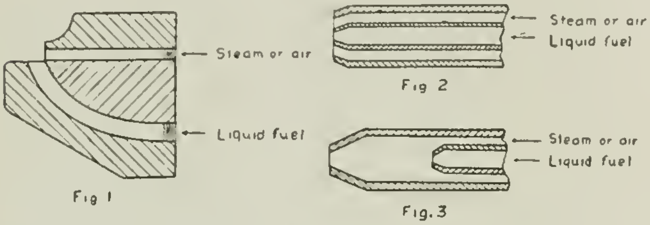
†Director, Physical Laboratory of the American Steel and Wire Company, Worcester, Mass.

While the use of liquid fuel has been adopted as a matter of expediency in some cases, the range of application includes open hearth; crucible, soaking pits; billet heating, forge, annealing, hardening and tempering furnaces; and a variety of furnaces for special heat treating operations. The use is also extended to a variety of furnaces used in the non-ferrous metal industry. The scope of this paper has been restricted to cover chiefly the use of liquid fuels to open-hearth furnaces and in furnaces particularly adapted to use in the wire drawing industry.



Figs. 1 to 3—Showing the principle used in some types of liquid fuel burners.

The use of coal tar and the heavier oils of 12 deg. to 20 deg. Be. requires careful heating of the oil in supply tanks so that they can be sufficiently reduced in viscosity to enable them to be pumped to the burner at the furnace. As heating vaporizes any light oils present, tanks should be vented at the top to permit of their removal from the system. The lighter oils having a density of 20 deg. to 30 deg. Be. are sufficiently fluid so that they may be pumped to the burner with little heating except in particularly cold weather. Heating of tar and heavy fuel oil is also essential in order to obtain proper atomizing of the oil at the furnace. Failure to provide sufficient heat to heavy fuel oil or tar cannot help but result in unsatisfactory results from the furnace in which it is used due to the failure of the burner to perform its proper function.

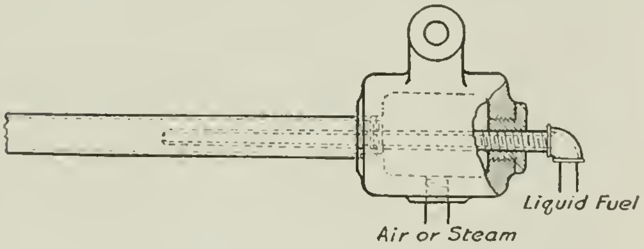


Fig. 4—Liquid fuel burner for open-hearth furnace.

After bringing the liquid fuel to the furnace under suitable temperature for atomizing, the success of using it depends on burner design, furnace construction, and the proper application of the burner to the furnace, so that the thermal value of the liquid fuel may be utilized at the proper time with the highest efficiency to produce the results required. For obtaining the highest thermal efficiency, it is necessary that burners be designed so that they will break up or atomize the liquid fuel into very minute parts in order that the greatest amount of surface may be offered to the air required for combustion.

In order to accomplish this purpose, many kinds of burners have been designed for private use or patented and placed on the market for general furnace use. These types of burners are intended to accomplish atomization by, (1) mechanically breaking up the liquid fuel into minute particles: (2) by breaking up the liquid fuel with an air or steam spray; and (3) by vaporizing. Attempts made to apply the last mentioned process to fuel oil by superheating to a temperature sufficient for vaporizing have not as yet been demonstrated as practicable due to the deposition of solid coke in the vaporizing chambers with consequent clogging of the system. Mechanical atomization, while practiced to a very large extent with steam boilers, has unfortunately not been developed for general application to metallurgical furnaces. Burners which find extensive use in metallurgical furnaces, however, are those types which accomplish atomization by spraying either with steam or compressed air under variable pressures dependent on furnace requirements.

There is quite a large field for using different principles in varying the design of burners which depend on steam or compressed air for atomizing the liquid fuel.

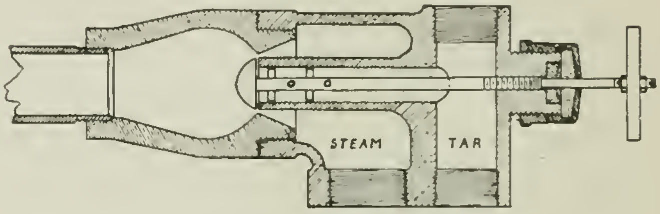


Fig. 5—Krause burner for liquid fuel.

A few of the principles which have been used in burner design will be described and illustrated so that a general idea may be obtained of the possibilities for variation. Atomizing burners are generally classified in two groups, one of which accomplishes atomization outside the burner, the other inside the burner. Fig. 1 illustrates a very simple arrangement whereby the steam or air jet passes directly over the oil jet, creating a suction effect which assists in the efficiency of atomizing outside the burner. Fig 2 illustrates another principle in common use where the oil is supplied through a central pipe to the tip of the burner. The steam supply running also to the tip of the burner surrounds the oil supply line. Atomizing is, therefore, accomplished externally in the furnace. Fig. 3 shows a burner with a chamber beyond the end of the fuel nozzle and provides for atomizing before the fuel enters the furnace. This type of burner may be altered so that the air and oil chamber has a Venturi shape and is known as the injection type. This principle is used with the idea of obtaining velocity in assisting to atomize the liquid fuel. Either steam or air may be used for atomizing with any of these general types of burners. The shape of the nozzle may be round or flattened in almost any type of burner to meet the requriements of furnaces for special purposes.

The pressure of air or steam required for atomizing with any burner is dependent on the furnace design and the character of the liquid fuel. Air pressure for the lighter oils may be as low as a few ounces per square inch where small furnaces are used. With the heavier liquid fuels, where steam is commonly used, the pressure on the line may run as high as 140 pounds per square inch.

Use of Liquid Fuels in Open-Hearth Furnaces.

The price of fuel oils in localities where large tonnages of open-hearth steels are produced is usually so high as to prohibit its use in competition with producer gas. The supply of by-product coke oven coal tar, however, ranging in quantity with different kinds of coal from approximately five to 13 gallons per ton of coal used, is available in sufficient quantities and at prices which make its use economically attractive, as far as the supply lasts, for use either alone or in combination with coke oven gas in open-hearth furnaces. Where the open-hearth practice has been developed for the use of tar alone or in combination with coke oven gas with consequent closing down of the gas producers, fuel oil may be substituted for tar to permit continuous furnace operations if the regular supply of coal tar is interrupted for short periods of time. As the equipment necessary for using tar is similar to that used for oil, such a change may be quickly accomplished. It is a good plan, however, when making such a change to clean out the system with steam under high pressure in order to free the pipes of any carbonaceous deposits which may have collected in them.

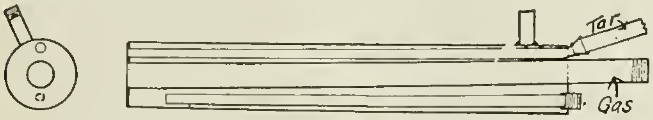


Fig. 6—Combination water-cooled tar and coke oven gas burner.

Installations of special equipment for handling liquid fuels are required, the cost of such equipment, however, being comparatively moderate. Storage tanks of variable capacity will be required to meet the demands of the individual plant. The use of large storage tanks at by-product coke oven plants, however, makes it unnecessary to provide large tank installations at the open-hearth plant. Where fuel oil is depended upon alone, possible delays in transportation due to distance from supply stations may necessitate very large storage tanks for even moderate sized open-hearth installations. All storage tanks for tar and the heavier fuel oils must be equipped with internal steam coils in order to supply sufficient heat to decrease its viscosity to such an extent that it may be readily pumped through the furnace supply pipes and be better atomized at the burner. The installation of a regulator in the steam line is of considerable benefit in maintaining proper temperature. The temperature of the tar in the tank found most desirable in practice varies from 125 deg. to 150 deg. F. The temperature used for pumping and free circulation of heavy fuel oils is usually around 10 deg. F. Higher temperatures tend toward the deposition of hydrocarbon which may cause clogging of the burner. Lower temperatures cause poor atomization and, therefore, dripping at the burner with consequent loss of thermal value.

When unloading from tank cars, strainers for removing solid mechanical impurities are placed in the pipe line to the tanks if unloading is accomplished by gravity or in the suction line of pumps when it is necessary to use the latter means of unloading. Such straining is usually through baskets of 3/16-in. mesh screens, set in suitable castings in the pipe line.

The liquid fuel is pumped from the supply tanks through pipes to the various furnaces. Pumps installed for this purpose are of both the duplex and triplex type, governed to maintain a steady pressure on the line. Where trouble is experienced with pulsations, relief is sometimes found by applying compressed air directly to the tank. All pumping equipment should be in duplicate in order to prevent serious delays in furnace operation during periods when it is necessary to make repairs to the pumps. When steam is depended upon for pumping, an auxiliary electrically driven pump will provide additional flexibility in case of breakdown or vice versa.

In order to convey tar and the more viscous fuel oils to the furnaces, pipe lines are arranged so that, after the various furnaces have been supplied, the line is returned to the pump. It is necessary in some cases to pump as much as 50 per cent more fuel than is actually consumed by the furnaces. Both the supply and return lines should be run parallel with a steam line and the three enclosed with a heavy asbestos covering to prevent cooling of the fuel during circulation. The size of lines for the fuel should usually not be less than three inches in diameter as smaller lines cause too much restriction to oil flow. Since storage tanks are generally isolated from the open-hearth building, it may be necessary to reheat the fuel as soon as it enters the building. A steam jacketed heater is satisfactory for this purpose. Reheating of the liquid fuel with a similar steam heater may also be necessary at the furnace, before the fuel enters the burner.

A practice whereby a limited amount of cheaper high sulphur fuel oil may be used in connection with the more costly low sulphur oil without detriment to the quality of the finished product has been in use for a number of years at an open-hearth plant in the east where the cost of fuel oil justifies its entire use in preference to producer gas. The high sulphur oil obtainable has a density averaging about 15 deg. Be. and is handled through a circulating oil system as described above. This oil is circulated at about 150 deg. to 160 deg. F. The low sulphur oil, averaging 25 deg. Be. and being considerably less viscous, is supplied to the furnaces through one pipe line which is dead ended after supplying the last furnace in the system. The temperature of the lighter oil at the pumping station varies from about 90 deg. to 100 deg. F. The furnaces are operating entirely with a cold pig iron and scrap practice. During melting down of the charge, low sulphur oil is used entirely. After the slag completely covers the charge, high sulphur oil is used for the completion of the heat. The furnace supply lines for both the high and low sulphur oils are brought together just before reaching the three-way reversing valve. Valves for shutting off either the high or low sulphur oils, as the practice demands, are conveniently arranged in the separate oil lines just before the two supply lines are joined.

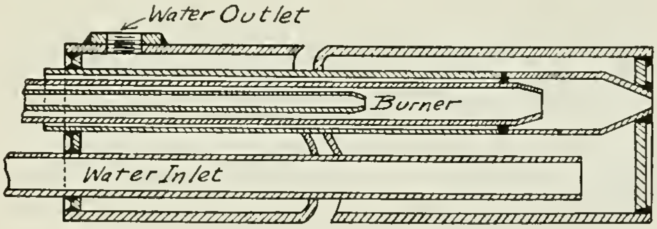


Fig. 7—Water-jacketed liquid fuel burner.

As tar is more difficult to atomize than even the heavier fuel oils, the type of burner used is worthy of considerable attention. The most common type of burner used for atomizing tar is illustrated in Fig. 4, where the tar is introduced through a central nozzle with the steam chamber entirely surrounding it. With burners of this type, various alterations of design have been tried with the idea of increasing the efficiency of atomization by inserting a valve spindle through the tar supply pipe, and attaching a ball or cone to the spindle at the fuel orifice. The ball or cone diverts the tar directly into the path of the steam giving better opportunity for atomization. Another modification of this burner may be obtained by plugging the end of the nozzle and drilling holes at various points throughout its circumference through which the liquid fuel is forced into the path of the steam.

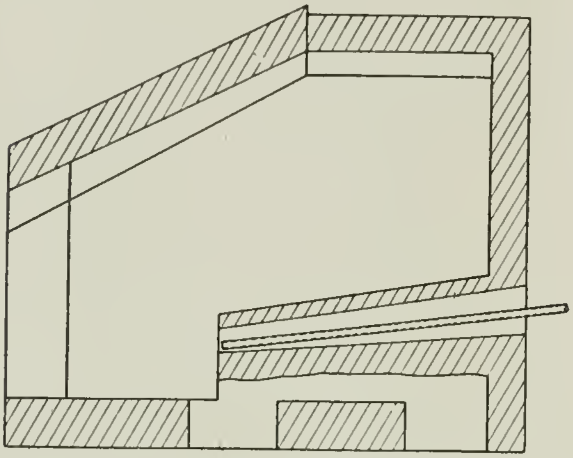


Fig. 8—Oil burner in brick tunnel through end of open-hearth furnace.

Fig. 5 illustrates a burner, designed and patented by Mr. Krause of the South Chicago plant of the Illinois Steel Company, intended primarily for increasing the efficiency of atomization when burning tar. Its construction lends itself readily, however, to the application of atomizing fuel oils with great efficiency. It is quite simple in design but very effective in atomizing tar. The tar supply passes through the central part of the valve to the button at the end of the valve stem where it is sprayed in fan shape into the path of the steam. Small projections from the valve stem to the wall of the valve prevent vibrations. The steam chamber is conicled in the direction of the tar outlet so that maximum velocity is obtained at the area of contact between the tar and oil. The atomization of the tar accomplished in this burner proves very effectual as judged by combustion conditions within the furnace. The burner also has the advantage of being quickly cleaned by screwing the valve stem in or our if clogging occurs at the tar orifice.

The steam pressure on the line supplying steam for atomization varies from 50 to 125 pounds per square inch, dependent on furnaces and burner construction. Likewise, the amount of steam per gallon of oil atomized varies from about three to six pounds. Dry steam is essential for good atomization, steam separators being used where necessary at advantageous positions on the line to obtain this condition. While the amount of steam seems relatively small, it is an item which should not be neglected in determining the type of burner to be used. Compressed air has not proven satisfactory for the atomization of tar. As fuel oils can be atomized with compressed air, however, tests have been conducted at an open-hearth plant using fuel oil only to determine whether steam or compressed air was cheaper. Such tests showed a net saving of seven per cent in the amount of fuel oil consumed in favor of compressed air, using a type of burner found to give consistently good results in furnace operation.

With the temperature conditions existing on the ends of an open-hearth furnace, it is necessary to provide some means of preventing the burner from being destroyed. This may be accomplished by providing mechanical means of swinging the burner out of the furnace when not in use; by placing the burner within a water jacket; or by building a tunnel, which may or may not be water jacketed, into the end of the furnace. As the majority of open-hearth furnaces on which liquid fuels are now used were designed primarily for the use of producer gas, there is commonly not sufficient space between furnaces to permit of the use of swinging burners.

In cases where tar is to be used in combination with coke oven gas and the introduction of both fuels has been found to give the best results when admitted into the end of the furnace, the gas burner and tar burner are combined in the same water jacket as illustrated in Fig. 6. Coke oven gas, due to being very light, is always introduced under the tar or oil, the heavier liquid fuel acting as a blanket to keep the lighter gas from rising and burning at the roof of the furnace with consequent short life of the furnace roof. The objection to using a burner of this type is that the tar and steam both must pass through a long atomizing chamber surrounded with water. The cooling effect of the water tends towards both condensation of the steam and liquefaction of the tar. The shape of the gas tip used with the combination coke oven gas and tar burners is either round or flattened. As the details of furnace construction vary, it will be necessary to determine by experiment whether the coke oven gas will give better results with either the round or flattened nozzle.

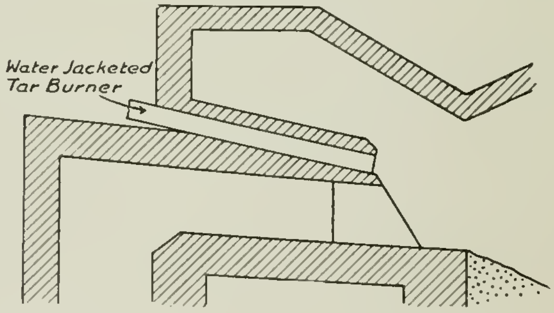


Fig. 9—Tar burner in producer gas furnace.

With furnaces designed for introducing tar alone at the ends of the furnace, a water jacketed burner similar to that illustrated in Fig. 7 may be used. This type of burner does not possess the objectionable feature of bringing the burner chamber in direct contact with the cooling water. A similarly designed water jacket may also be used in connection with the combination tar and coke oven gas burner.

A brick tunnel may be built into the furnace from the end wall as shown in Fig. 8. The high temperatures existing in the furnace may necessitate water-cooling in order to insure necessary life of the tunnel. In some furnaces, however, using fuel oil and having a tunnel similar to that shown in Fig. 8, a small amount of steam, insufficient to interfere with furnace operation, is kept passing through the unused burner, neither burner or tunnel being water-cooled.

The extent to which changes in design of furnace ends is justifiable is in a measure determined by the quantity and type of liquid fuel available. Fig. 9 illustrates a method used for introducing a tar or oil burner into the end of a furnace designed for use with producer gas. Other features of furnace design may require the burner to be introduced so that its tip partly extends into the gas port, instead of taking the position shown in Fig. 9. In very large furnaces, better fuel distribution may at times be had by using two burners on each end of the furnace, each burner being located toward the side wall of the furnace.

Where a steady supply of liquid fuel is available, the construction of the furnace ends may be considerably simplified as illustrated in Fig. 10. With this design, the air for combustion is admitted through two uptakes at the corners of the furnace and the cinder pockets are combined into one chamber. Both checker chambers at each end of the furnace are utilized for heating the air. Fig. 8 shows the modification of port construction applied to a 50-ton oil burning tilting furnace.

The location of the burner in the furnace for either tar or fuel oil is of great importance, and in practice differs as to the height above and angle which it makes with the bath line and the length introduced into the furnace. It should be placed so that luminosity is obtained as soon as the fuel reaches the furnace hearth. In connection with this, it is important that the burner be so placed and the port ends so constructed that proper direction of atomized fuel and air for combustion will give the most efficient melting down and prevent melting of the roof. As different types of burners vary in the thoroughness of atomization, the type of burner used will have some bearing on its location.

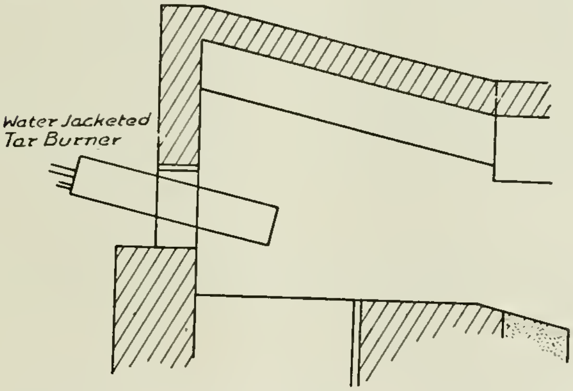


Fig. 10—Design of open-hearth furnace end for tar burning.

The use of a satisfactory quality of liquid fuel alone requires little or no changes in open-hearth practice. It has been used with furnaces up to 200 tons capacity. The quantity of fuel consumed per ton of ingots produced will, however, vary according to the open-hearth practice used at different localities. Furnaces operating with a combination coal tar and coke oven gas practice use variable percentages of each, depending on local conditions. Commonly, however, about 50 per cent of the heat required is derived from each source. Some plants have experienced a reduction of 10 to 15 per cent in the time of heats under similar conditions and a reduction in furnace repairs, as compared with furnaces operating with producer gas. Where waste heat boilers are installed, the less volume of gases from liquid fuel burning, as compared with furnaces operating with producer gas, results in a less amount of heat available for use in the boilers.

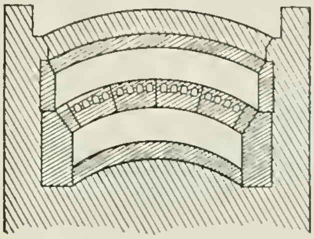


Fig. 11—Cross section of earlier type of coal fired, old process patenting furnace.

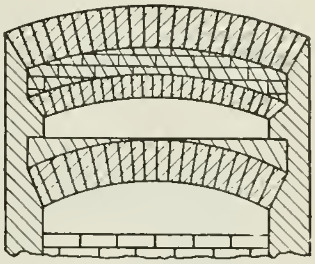


Fig. 12 — Later design of coal fired, old process patenting furnace.

Application of Liquid Fuel to Heat Treatment of Wire Products

Fuel oil has proven of considerable value in its application to furnaces used in the continuous heat treatments of both high and low carbon steel rods or wire. The heat treatments in common use in the production of steel wires are patenting, hardening and tempering, and annealing. The two latter treatments mentioned are quite familiar. The patenting process, however, finds its chief commercial application throughout the wire producing industry. A brief discussion of the patenting process will serve to indicate the adaptability of fuel oil to the furnaces required to carry on this heat treatment. The patenting process is intended to impart to the wire a uniform degree of toughness and temper which will permit of drawing the wire through dies to obtain the proper size and quality demanded for various commercial purposes. The patenting process of wire is accomplished by two general methods. One of these types is known as old process patenting, in which the wire or rod is continuously passed through a furnace, where it is required to reach a temperature of approximately 1,700 deg. F., after which it passes out of the furnace, through unrestricted air space, to be again wound on reels to facilitate handling. The second type of patenting is known as double lead patenting, in which the wire or rod is passed continuously through a hot metal bath, usually lead, where it is heated above its critical temperature and passes immediately into another lead bath having a temperature below the critical temperature of the steel. Each of these processes has its particular use in the production of various grades of wire for definite commercial uses. The double lead process, however, on account of obtaining better temperature control surpasses in permitting the production of high carbon wires of great strength and toughness.

With the introduction of old process patenting to the wire industry, furnaces were generally designed for the use of coal, except where natural gas was available, and coal fired furnaces for this purpose are still used where economic conditions are favorable. The process requires that a large tonnage of cold rods or wire pass through the furnace and exit at comparatively uniform temperatures. Early furnace designs, such as illustrated in the furnace cross section of Fig. 11 provided for a large amount of brick work which acted as a reservoir for radiating heat to the rods or wire as they passed through the tubes. Heat was supplied from a coal fire at the end of the furnace, the gases supplied from a coal fire at the end of the furnace, the gases passing under the tube brick arch to the opposite end of the furnace, returning the full length of the furnace over the top of the tubes and then passing to the flues. A later development of the furnace is shown in Fig. 12 and eliminates the tube brick arch, providing, therefore, for the passage of the wire directly through the furnace gases. While the latter design reduced the cost of coal per ton of product, furnace temperature control was no better than with the original type of furnace and the possibility for fluctuations of temperature during cleaning of fires still existed. By using fuel oil, furnace designs for old process patenting could be readily varied in order to utilize the full effects of the heat of combustion at a position in the furnace which would most favor thorough heating of the wire or rods to the desired temperature. The design of a patenting furnace in which very efficient heat treatment is performed is illustrated in Fig. 13. The arch in the furnace is somewhat similar to that of a longitudinally bisected frustum of a cone, using the bisected plane as a base. The burner is introduced in the end of the furnace at the narrow end of the cone and is of the type illustrated in Fig. 2 with a nozzle of sufficient length to extend within the furnace wall. Air for combustion is admitted around the burner. Dry steam under 125 pounds pressure is used for atomization. The maximum temperature generated within the furnace is obtained at the most desirable position in the furnaces or just before the wire passes out of the furnace into the air. The furnace gases pass over the top of the arch and exit into a flue on the same end of the furnace in which the burner is placed. As the wire travels in the opposite direction to the furnace gases, opportunity is presented for both gradual heating of the wire and utilization of heat in the waste gases.

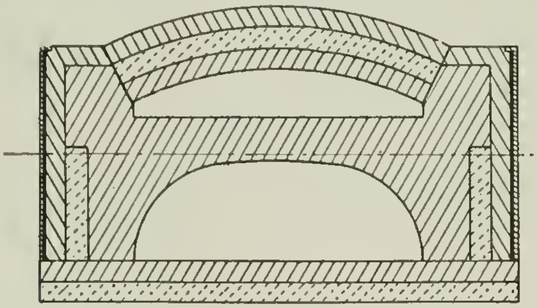


Fig. 13A—Cross section of old process patenting furnace.

The same type of furnace is utilized for heating the lead kettle when the double lead patenting process is used. A perforated brick arch is placed in the area marked "B-B" Fig. 13 B on which the lead kettle rests. The hot gases pass up through the interstices of the arch, entirely surrounding the bottom and sides of the kettle, after which they leave the furnace in the same manner as described above, supplying an opportunity to utilize the waste gases for reheating the wire before it enters the lead kettle. The colder lead bath used with this process obtains the greater proportion of its heat from the hot wire entering it although additional heat may be bypassed from the hot lead kettle furnace, if necessary, to the colder lead kettle.

If the cold lead pan is removed from the end of the furnace and replaced with a trough through which is circulated a supply of quenching oil, then we have an oil-fired continuous hardening equipment. For drawing the temper, a separate oil-fired lead kettle is arranged back of the quenching oil troughs. The same design with lead kettle in place may further be used for the continuous annealing of wire in lead.

Furnaces of this type consume much smaller quantities of fuel per hour as compared with open-hearth furnaces. Burners are, therefore, smaller in all details and the possibilities for clogging of burners due to mechanical impurities in the oils is much greater than experienced where consumptions are quite large as in open-hearth practice. Greater care must, therefore, be exercised in keeping a clean supply of oil flowing at all times.

With large tonnages of wire or rods to be handled, it is desirable to segregate similar heat treating equipment and use several separate oil supply systems rather than attempt too large an individual installation. The arrangements for supplying fuel oil to the various furnaces have been described with this idea in mind.

While fuel oils having a density averaging 15 deg. Be. require the use of an elaborate system for handling, their cheapness as compared with the lighter oils justifies the installation required for handling them for furnaces of the above type.

Fuel oil is brought to the storage tanks by tank cars where it is unloaded by pumps having strainers in the suction line. It is not customary to pump from storage tanks directly to the burners as intermittent unloading of oil is too likely to cause a general drop of temperature in the storage tank which would interfere with circulation and atomization. Transfer pumps are, therefore, used to pump the fuel oil from the storage tank into the tank in which it is to be used for furnace supply. Steel tanks used for mill supply are usually placed underground in concrete pits as this assists in keeping the oil at the desirable temperature for pumping. As it is necessary to have each tank vented, vents have been surrounded with small circular steam pipes having jet holes several inches apart pointing towards the center for the purpose of smothering the fire in case of ignition. Steam valves for controlling this feature have been placed conveniently at considerable distance from the tanks. Both sets of tanks are equipped with steam coils for heating the oil and all pumps are in duplicate to avoid delays in case of the necessity for repairs.

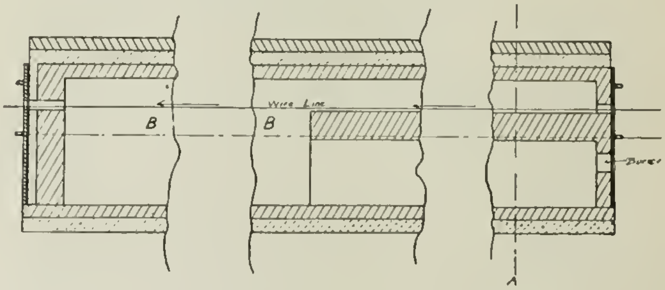


Fig. 13B—Longitudinal section through middle of old process patenting furnace.

As straining is of great importance with small oil consumption per burner, strainers are inserted in the suction line of both the transfer and mill supply pumps, in order to afford all the opportunity possible to remove mechanical impurities. Strainers used for this purpose are illustrated in Fig. 14 in which a cylindrical basket made from wire gauze having 25 meshes per inch is used. Each pump has two strainers with suitable valve arrangements in the suction line so that the strainers may be cleaned without interruption to pumping. Both pumps and strainers when located in places subject to severely cold weather are steam jacketed.

The fuel oil is circulated as described for tar or heavy fuel oil at open-hearth plants with the same provision for combining the supply and return oil line together with a steam line. A stand-pipe of the same diameter as the supply line is, however, inserted in the return line of the system. The stand-pipe acts as a reservoir and also serves to reduce the effects of pump pulsations which are particularly aggravating with small oil consumptions per burner. A valve is placed at the top of the stand-pipe to regulate the amount of oil returned. Oil supplied under a pressure of 35 to 40 pounds per square inch and steam under pressure of 125 pounds per square inch give the most satisfactory operating conditions. Dry steam is not only desirable but essential and steam separators are used in the line where necessary.

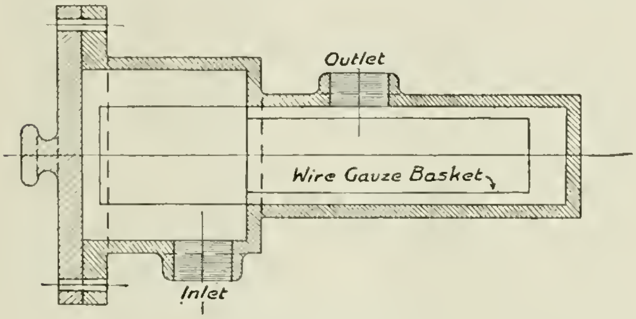


Fig. 14—Oil strainer.

The above describes the system used for handling heavy fuel oil for several supply systems, accommodating a fairly large number of furnaces. The lighter fuel oils may be handled with less attention to their temperature. Where small heat treating furnaces are required for use in isolated places, the lighter grades of fuel oil requiring no elaborate methods for handling can be utilized quite favorably by the installation of a small pressure blower and fuel tank, the blower supplying both the air for atomization and pressure for forcing the fuel from the tank to the burner.

Conclusions.

Liquid fuels when available at satisfactory prices may be adapted to a large variety of furnaces used in conducting metallurgical operations. The relatively small initial expenditure required for its application and the ease of manipulation of furnace temperatures make the use of liquid fuels quite attractive. Success in using this type of fuel depends on furnace design, proper methods for its distribution to the furnace, and on burners which will thoroughly atomize the fuel. In the future development of the use of liquid fuel for metallurgical furnaces, there are at least two important principles to consider in an effort to obtain further economy. One of these is the adoption of the principle of mechanical injection now used quite extensively with boilers, and the other, the use of the recuperative principle wherever it can properly be applied in the construction of furnaces which now obtain their air for combustion at atmospheric temperatures.

USE OF OXYGEN IN METALLURGICAL OPERATIONS

Use of oxygen in connection with the enrichment of the blast in the blast furnace and in practically all phases of pyro-metallurgical work will furnish the key to success in the further development of such metallurgical operations, according to Dr. F. G. Cottrell, formerly director and now consulting metallurgist of the United States Bureau of Mines, who first directed the bureau's attention to this subject. Through this enrichment process, it is hoped to increase the efficiency of metallurgical operation with a resultant production of metals at lower cost and possibly the use of lower grade ores.

The Bureau of Mines now has outlined plans for two studies which will be carried on simultaneously. The first will cover the present-day processes for the production of oxygen, in order to determine the feasibility of attempting to produce oxygen, or oxygenated air, in such amounts and at such a cost as to permit of its use in metallurgical operations. The second study will be devoted to the feasibility of using oxygen, or oxygenated air, in metallurgical operations.

Because of his interest in this investigation, M. H. Roberts, vice-president of the Franklin Railway Supply Company, was asked to select an advisory committee to work with the Bureau of Mines and to act as chairman of this committee. The committee will consist of Dr. F. G. Cottrell, director of the Fixed Nitrogen Research Laboratory; Prof. W. L. DeBaufe, chairman of the mechanical engineering department of the University of Nebraska; Dr. D. A. Lyon, chief metallurgist of the Bureau of Mines; Dr. R. B. Moore, chief chemist of the Bureau of Mines; Dr. R. C. Tolman, professor of physical chemistry and mathematical physics, California Institute of Technology; J. W. Davis, mechanical engineer of the Bureau of Mines; F. W. Davis, metallurgist of the Bureau of Mines; Frank Hodson, president of the Electric Furnace Construction Company, and P. H. Royster, assistant metallurgist of the Bureau of Mines.

Previous to the war, some work was done in Belgium on the enrichment of the blast with oxygen in connection with the smelting of iron ores in the blast furnace. In the United States, the late J. E. Johnson, Jr., was interested in the possible use of oxygen in metallurgical operations and carried on some experimental work along these lines previous to his death

MEETING OF ELECTRIC STEEL FOUNDERS' RESEARCH GROUP

The chief executives and the operating officials of the companies comprising the Electric Steel Founders' Research Group recently held a three-day meeting at Wernersville, Pa., at which exhaustive progress reports were presented on researches being conducted by the organization into annealing, core practice, facing practice, furnace practice, and the elimination of slag from castings.

The group members report that the standardization of practices has recently been extended to cover methods of chemical analysis.

Heating Furnaces for Blooms, Slabs and Billets[*]

Selection of Fuels—Types of Furnaces—Efficiency Tests—Recommendations with Respect to Roof, Hearth, Skids, Burners, Regulators and Meters, Pusher, Roof Recuperator, Discharging and Charging Mechanism, Insulation, Water Cooled Devices, Etc.

By W. P. CHANDLER, JR.[†]

I HAVE been asked to prepare a paper on "Heating Furnaces for Blooms, Slabs and Billets," with special attention to fuel economy. If taken broadly, this subject would include all types of furnaces with the different methods for firing the various fuels in use. I shall, however, cover briefly the various methods of firing metallurgical heating furnaces, and describe particularly two certain types of furnaces with which I am particularly acquainted. These furnaces use by-product coke oven gas as fuel, but conclusions can be drawn from the results of tests, that may be applicable to future development of furnaces using any type of fuel in order to obtain more efficient and better heating.

Selection of Fuels.

The choice of fuels for use in heating furnaces is governed by availability and cost. When natural gas was plentiful and cheap practically no other fuel was used, but with the growing scarcity of this fuel, operators have been forced by considerations of cost and even by law to substitute other fuels.

The gaseous fuels such as natural or by-product gas are ideal fuels for use in heating furnaces. They require the least amount of equipment; a gas main, regulator and burners with necessary valves make a complete installation. The varying demand of the furnace can readily be met with an increase or decrease in the supply of fuel, while the temperature of the furnace can be held at any point within the range required for heating steel. The most important factor governing the successful use of a gaseous fuel is the maintenance of a constant pressure on the burner valves. This can be accomplished by the installation of an automatic pressure regulator.

Liquid fuels such as by-product tar and fuel oil require additional equipment. A storage tank equipped with some means of heating the fuel, such as pipe coils filled with steam, a pump, pressure regulator and atomizing burners with the necessary piping and valves make up the usual installation. The atomizing burners may be of the pressure type or may require steam or compressed air, in which case a source of supply for the atomizing agent must be provided. As in the case of gaseous fuels, constant pressure for both fuel and atomizing agent are requisite for good operation of the furnace. The main reasons these fuels have not found broader use lies in the scarcity of by-product tar and the cost of fuel oil at the main steel mill centers.

Solid fuel in the form of coal has been used in many reverberatory heating furnaces. Originally, the firing was done by hand and the ashes removed by manual labor. The high labor cost in this country has forced the development of labor saving devices. The mechanical stoker has found ready application and a large number of furnaces are operated in this manner at present. The installation, aside from the stoker proper, requires the addition of coal and ash handling machinery, bins and in the case of forced draft stokers, the necessary fans and air ducts. It also precludes to a great extent the savings that can be obtained from recuperation of the air for combustion.

Another development in the application of coal as fuel for heating furnaces has been through the use of gas producers. By this method the preparation of the fuel is removed from the furnace and the heater has to deal with only a gaseous fuel. Only about 80 per cent of the heating value of the coal is realized in the producer gas, however, and with the rapidly rising cost of coal in this country it will become more and more difficult to justify this loss. There is a large increase in the initial cost of the furnace installation to provide the producers, building, coal and ash handling machinery, gas flues and steam lines. A general estimate of the cost can hardly be made, since much depends on the individual installation. The size of the producer plant, location with reference to furnaces served, number of furnaces to be operated from one producer plant and such items require that a separate study be made for each case. The cost of operating the producer plant, that is gasifying the coal, must be added to the fuel cost in any comparison of prices of various fuels.

In recent years powdered coal fired heating furnaces have found favor in many plants, particularly in France. A number of problems in its use will have to be overcome successfully before its adoption will become general. Removal of the ash from the products of combustion or provision for its free passage through the furnace must be provided in order to insure uniform heating of the steel. The intense flame with its consequent cutting action on the steel must be cared for, and the gain in efficiency due to preheating the air for combustion will increase this difficulty by causing a still more intense flame. A number of methods and systems for pulverizing, conveying and firing powdered coal are on the market, and if the various difficulties can be successfully overcome, material savings in fuel may be obtained.

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[*] Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

[†] Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

The application of electrical heating in metallurgical work is comparatively new. Furnaces using electrical heat for heat treatment of steel, either as castings or forgings, are successful and on account of the accuracy with which the desired temperature may be maintained and the freedom from oxidation, it is found that it pays to use the more expensive fuel for source of heat, electricity. It is doubtful if electricity will be used to heat steel in the form of blooms, slabs and billets made of ordinary steel, except in special localities where electricity is cheap and fuel is scarce and expensive. However, where steel is placed in a furnace hot and merely receives a soaking heat, as in the case of ingots in soaking pits, the amount of electric current required per ton of steel is small and it is probable that the saving due to freedom from oxidation or scale and from burnt steel will more than compensate for the cost of the electric current. Such electrically heated soaking pits have been designed, although they are not in operation at the present time.

The following table has been prepared to show the allowable price that can be paid for variuos fuels to be equivalent in heating value to natural gas at $0.30 per thousand cubic feet. The cost of preparing and firing the fuels has been added in arriving at the allowable price, but no allowance has been made for the efficiency obtained in the furnace itself. Also no charge for depreciation or interest on the initial investment has been made, since so much depends on the individual installation.

	Fuel				
Unit	Natural Gas 1,000 Cu. Ft.	By-Product Gas 1,000 Cu. Ft.	By-Product Tar 1 Gal.	Fuel Oil 1 Gal.	Coal as Producer Gas 1 Gross Ton
Btu. per unit delivered at heating furnace	950,000	496,000	156,000	137,600	24,192,000
Equivalent of 1,000 cu. ft. of natural gas	1,000	1,915	6.09	6.90	.03926
Cost of preparing per unit	00	00	$.00023	$.00023	$1.60
Cost of firing per unit	00	00	.005	.004	....
Total cost of equivalent of 1,000 cu. ft. of natural gas	$.30	.30	.30	.30	.30
Cost above fuel of equivalent of 1,000 cu. ft. of natural gas	00	00	.0304	.0276	.0628
Allowable cost equivalent of 1,000 cu. ft. of natural gas	.30	.30	.2696	.2724	.2372
Allowable cost per unit to be equivalent to coal cost of 1,000 cu. ft, of natural gas	.30	.157	.044	.040	6.04

Types of Furnaces.

There are two main types of furnaces in use for heating blooms, slabs and billets, the continuous and the non-continuous. The latter is similar in construction to the Siemens open-hearth furnace, the direction of the gas flame across the hearth is periodically reversed and the furnace is usually equipped with regenerative checker chambers for preheating the air used for combustion. The blooms or slabs which this type of furnace usually heats are charged on the hearth of the furnace and remain in the one place till hot enough to roll. The continuous furnace is not reversed, the flame always traveling in the one direction, while the steel usually in the form of billets, passes through the furnace in the opposite direction. The cold billets enter the furnace at the coolest point and are pushed forward to the point of maximum temperature where they are discharged to the rolls. In the continuous furnace the billets lie tight together on the skids, forming a large steel plate on the floor of the furnace. Only the top of the billet is exposed so that all the heat required to bring the steel to rolling temperature must be absorbed by this surface. In the non-continuous furnace there is an open space between the blooms, so that three sides are available for directly absorbing the heat from the products of combustion or roof, while the fourth side is resting on the heated hearth of the furnace and absorbs from it a large amount of heat.

The time required for heating billets, slabs or blooms depends on the temperature of the heating medium, the surface of the steel exposed and the thickness of the steel. The temperature of the continuous furnace is at a maximum only at the discharge end and gradually decreases to the rear, while only one side of the billet is available for absorbing heat. In the non-continuous furnace the temperature is at the maximum throughout and three sides of the billet are available for absorbing heat. It is evident, therefore, that the same sized billet must remain longer in the continuous than in the non-continuous furnace. The dimensions of the non-continuous furnace do not affect directly the time of heating, but in the continuous furnace, with the rolling mill handling a given number of bars per hour, the length of the furnace fixes the time of heating. With everything else the same, the time of heating in a continuous furnace varies as the square of the thickness of the billet, so that a five-inch square billet requires four times as long as a two and one-half inch square billet. This means that for the larger sizes of billets long furnaces are required to give the capacity required by the rolling mill. For blooms and slabs the general practice so far has been to use non-continuous furnaces, but for 5 by 5 inch billets and smaller the continuous furnace proves very satisfactory.

Certain of the alloy and spring steels, if heated too rapidly, tend to crack, so that care must be used in bringing such billets up to rolling temperature. The continuous furnace fits this class of steel admirably since the billet enters a relatively cool part of the furnace and is gradually heated to the temperature required for rolling.

Non-Continuous Regeneration Furnace.

A sketch of a non-continuous regenerative furnace is shown in Fig. 1. The hearth which is 18 feet wide by 35 feet long has a silica bottom, made by fusing sand in thin layers until the proper thickness is reached.

A slight slope toward the rear of the furnace allows the slag which forms to drain through spouts into slag pots. The steel is charged and drawn through doors in the front by a charging machine. Four pots are provided at each end of the furnace, through which the gas with part of the air for combustion is admitted. The remaining air for combustion enters through a wide port opening between the roof and the top of the gas ports. Two regenerative checker chambers are provided at each end of the furnace, as producer gas was the fuel initially used and this gas was preheated

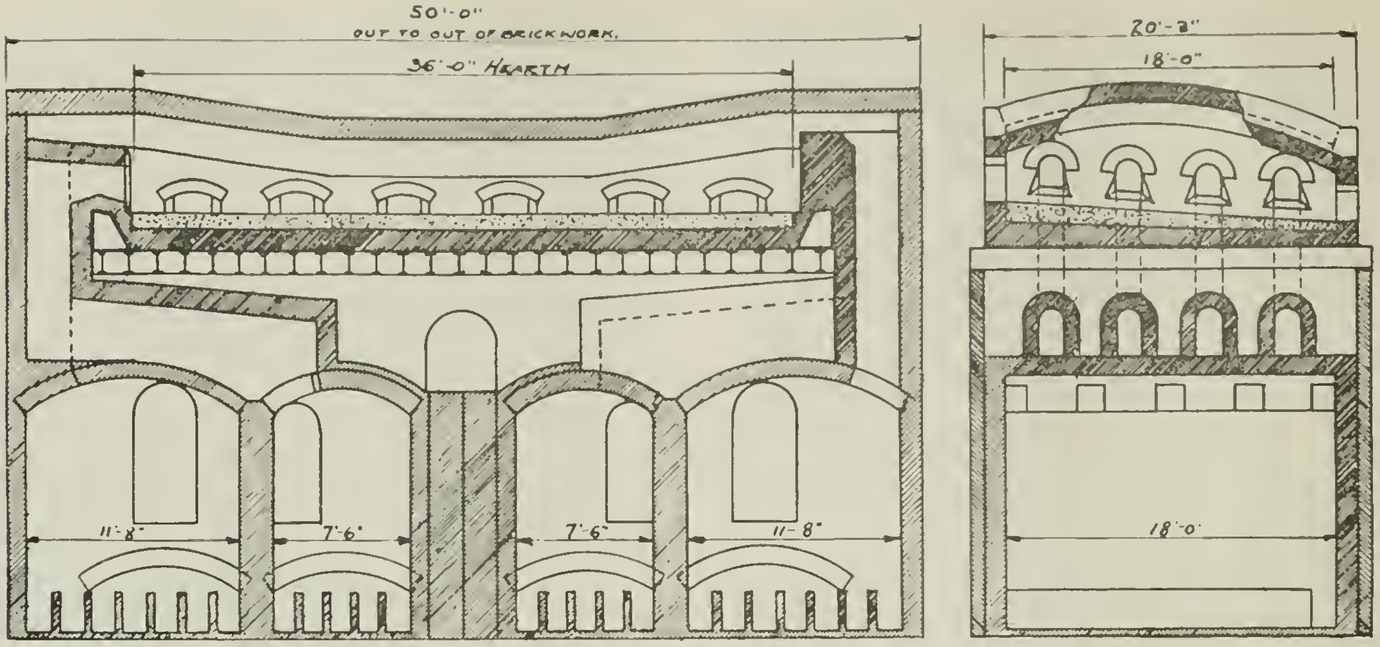

Fig. I—Non-Continuous Regenerative Heating Furnace.

as well as the air for combustion. The checker chambers are connected to the stack by flues containing valves and dampers, so arranged that the direction of the flow of the hot products of combustion across the hearth may be periodically reversed. In this manner the gas is first burned through one end of the furnace, while the waste gases leave at the opposite end, heating the checkers in their passage to the stack. The flow is then reversed, the gas is burned through the other end and the air for combustion is preheated in the checker chambers which have just received their heat from the waste gases.

Two of these furnaces serve one rolling mill. With one furnace containing steel heated and ready to roll, the first door is opened and the part of the hearth served by this door cleared of steel. Then the second door is started in the same manner, and while drawing the second door, the first is recharged. This is continued till all the hot steel has been drawn and the furnace refilled with cold blooms. The charging machine then moves to the second furnace and repeats the operation. By alternating the furnaces little time is lost waiting on hot steel. Blooms varying from 5 by 5 inches to 9½ by 11 inches are heated in this furnace.

Efficiency Tests of Non-Continuous Regenerative Furnaces.

Method of Testing: Efficiency tests conducted on the furnace just described were made in the following manner: The amount of by-product gas used as fuel was measured by a Wylie proportional meter, which was calibrated with a pitot tube for various rates of flow. The pressure of the gas was measured with a mercury U gage, the temperature with mercurial thermomenter, and samples were taken for chemical analysis from which the heating value was calculated. A record was kept of the number and size of blooms heated and the temperature of the steel leaving the furnace was measured by a Leeds & Northrup optical pyrometr. The steel entering the furnace was at atmospheric temperature. Analysis of the waste gases in the flues leading from the checker chambers to the stack were made with an Orsat apparatus. Four thermo-couples were installed, two at either end of the furnace, with one in each of the flues leading from the regenerative chambers to the stack. In this manner the temperature of the waste gases leaving each regenerative chamber was determined and the average of all readings used for calculating the stack loss. The temperature of the preheated air entering and of the waste gases leaving the furnace was obtained with an optical pyrometer sighted on the brick walls of the flues leading from the regenerative chambers to the ports, determinations being made on the air from each chamber. Readings were also taken of the furnace temperature with an optical pyrometer, and atmospheric temperature near the furnace with a mercurial thermometer. The barometric pressure was read during each test and the specific gravity of the gas checked periodically.

Readings of all instruments were taken every ten minutes during the test and samples of waste gas were analyzed every ten minutes.

The regular operation of the furnace consisted of a drawing and charging period followed by a heating period, which required that the starting and stopping point of the test be at the same point in the cycle in order that the gas supplied and the steel heated would bear the correct relation to each other.

Calculation of results: The following methods were employed in calculating the results shown in the following pages:

The heat absorbed by the steel was found from the weight of steel heated, the temperatures of the steel entering and leaving the furnace and the specific heat of steel which for these tests was taken as 0.166. The weight of steel was obtained from the number and weight of blooms entering the furnace. The heat supplied to the furnace was determined from the heat value of the fuel gas, as calculated from the chemical analysis and the number of cubic feet of gas burned reduced to standard condition of 2 deg. F. and 30 inches of mercury pressure.

The losses were calculated according to the usual engineering practice, the loss to radiation being taken as the difference between the heat supplied in the gas and the sum of heat absorbed by the steel and all losses except radiation.

The efficiency of the furnace as shown is the ratio of the heat absorbed by the steel to the heat delivered in the gas. The efficiency of the regenerator was calculated by assuming that all the heat in the gases entering the regenerator was available for absorption by the air. The difference between the heat content of the gases entering and leaving the regenerator was assumed as the heat absorbed by the air. The efficiency shown is the ratio of the heat absorbed by the air to the sensible heat of gases entering the regenerator.

From the analysis of the waste gases a study was made of the infiltration of air at various points. The amount of excess air in the waste gases leaving the regenerator was first calculated. The air entering the furnace through the ports was calculated by a heat balance of the regenerator assuming no radiation. This assumption is partially true because the regenerators are entirely under ground and are therefore very thoroughly insulated. The difference between the amount of air entering the ports and the amount of air used for combustion with the excess as shown in the regenerator gases is the amount of air that infiltrated through the doors and openings in the furnace.

Discussion of Results: From the tabulated results it will be seen that the efficiencies varied from 36 to 41 per cent. It is interesting to note that with the highest efficiency the following conditions prevailed: the lowest rate of heating steel, the lowest gas consumption, the lowest radiation and the lowest stack loss, while the reverse conditions prevailed on the test having the lowest efficiency. It will be seen that the greater rate of heating is accompanied with greater furnace temperature and the corresponding greater heat losses.

Continuous Recuperative Furnace.

A sketch of a continuous billet heating furnace equipped with a recuperator for preheating the air for combustion is shown in Fig. 2. The billets enter through a side door in the upper end of the furnace, passing into the furnace on rollers, are pushed forward on the skids of the furnace by a set of arms which operate through the rear end wall and are discharged through a small door in the side wall at the other end of the furnace by a pusher bar driven by pinch rolls. The discharged door is in line with the first pass of the roughing rolls, so that the billet enters the rolls before being completely discharged from the furnace. This design is possible where only one furnace supplies a mill. If two or more furnaces are used the billets usually fall from the hearth through the end of the furnace, upon the rollers of the transfer table. This design necessitates having an opening in the end of the furnace extending the full width. The opening is partially closed by swinging doors, bars or pipes, but allows a large amount of cold air to pass into the combustion chamber at the point where the billets are being heated to their highest tempearture.

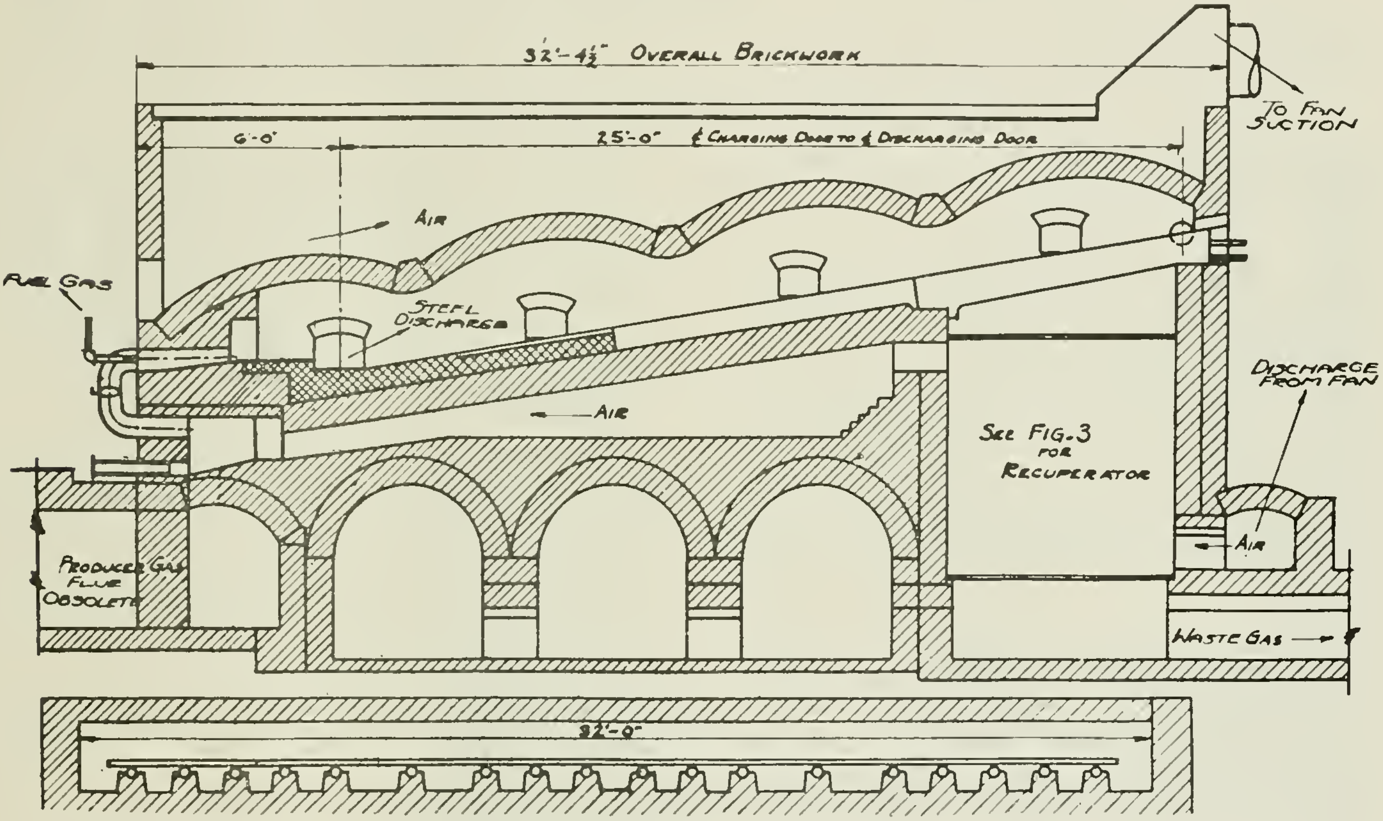
32'-4½" Overall Brickwork
6'-0"
25'-0" ℄ Charging Door to ℄ Discharging Door
To Fan Suction
Air
Fuel Gas
Steel Discharge
Air
See Fig. 3 for Recuperator
Discharge From Fan
Air
Producer Gas Flue Obsolete
Waste Gas
32'-0"

Fig. 2—Continuous Recuperative Heating Furnace.

The roof consists of four arches thrown in the direction of travel of the steel. The skewbacks for these arches are supported by a water-cooled system of pipes hung by straps from steel beams which rest on the side walls of the furnace. The side walls extend three feet above the arch. Steel trays filled with sand are placed over the beams forming an air space over the roof.

Water-cooled skids are used to bridge the opening

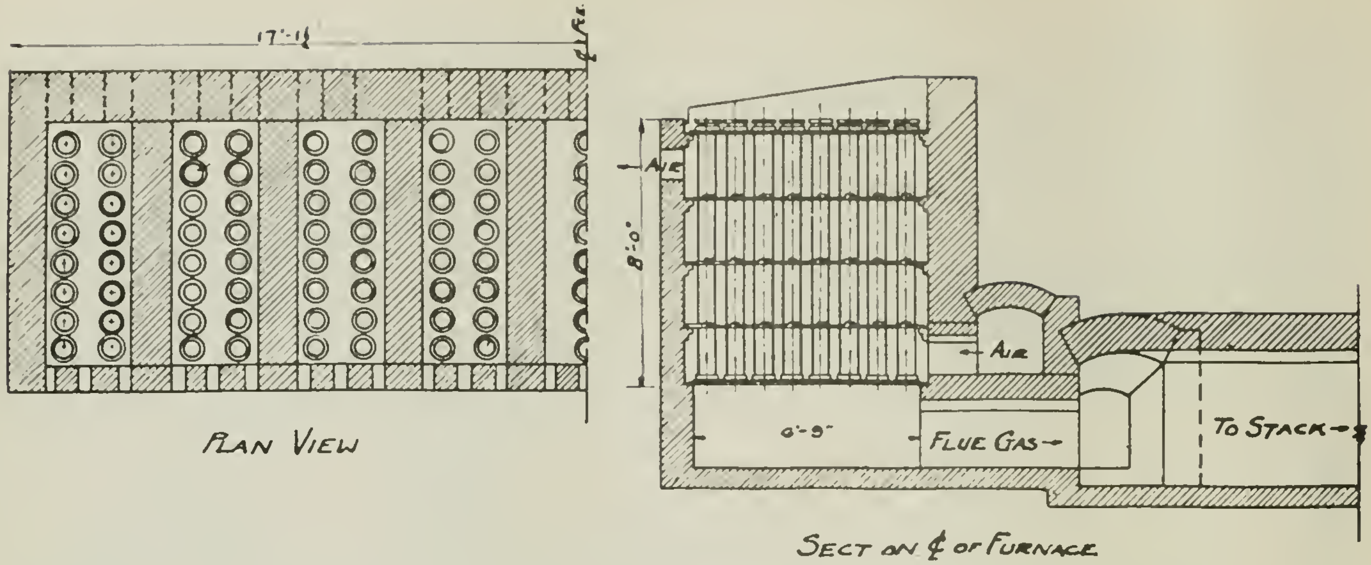

Fig. 3—Recuperator for continuous Heating Furnace.

into the recuperator chamber, but no water-cooling occurs beyond the point where the fire brick floor of the furnace commences.

Cast iron skids support the billets to within 3 feet of the discharge door where a magnesite brick bottom, built flush with the tops of the skids covers the floor of the hearth. The cast iron skids without water-cooling give excellent service.

Fifteen burners are provided across the end of the furnace. The burner consists of a cast iron return bend having a small gas pipe concentrically located in the upper leg, while the air for combustion is supplied through the lower leg which is provided with a butterfly regulating valve. Mixing of air and gas takes place beyond the nose of the gas pipe, the flame entering the combustion chamber through the ports of the furnace.

The recuperator for preheating the air used for combustion is shown in Fig. 3. It consists of vertical cast iron pipes supported by plates with additional baffling plates. The products of combustion pass downward through the pipes to a flue leading to the stack. The air used for combustion is partially heated by being drawn through the space between the roof of the furnace and the sand trays supported on the cross beams by a fan, which discharges through a flue into the recuperator chamber. The air passes upward on the outside of the cast iron pipes, receiving heat through the walls of the pipes. Leaving recuperator, the air passes under the floor of the furnace through ducts to the opposite end, where it enters the bottom leg of the cast iron burners. The furnace is used for heating from 1½ to 2½-inch square billets.

A second continuous billet heating furnace is shown in Fig. 4. This furnace has a flat roof which eliminates the water-cooling used on the skewbacks for the arched roof. It is also equipped with a brick recuperator. The downward passageways are square brick flues, while the air for combustion is baffled, in the manner shown, to make seven passes across the heated brick walls.

The brick recuperator has received a great deal of attention abroad and a number of special form tiles have been developed with which the recuperator is constructed. In one type, the recuperator chamber is located below the furnace. The air for combustion passes upward, by natural draft, through vertical rectangular flues, while the waste gases entering at the top travel through horizontal flues and make two passes across the outside of the air-carrying tile. Great care has been used to prevent leakage from the air passageways into the waste gas flues and the tile has been designed as thin as is consistent with the necessary strength.

Efficiency Tests of Continuous Recuperative Furnaces.

Method of Testing and Calculating: Tests were conducted on the two continuous recuperative furnaces just described in a manner similar to those conducted on the non-continuous regenerative furnaces with only the necessary changes due to difference in construction. The amount of cooling-water used was measured and the inlet and outlet temperatures noted. The calculations followed along the same lines as those described for the regenerative furnace.

General Discussion of Results: The continuous recuperative furnaces are more efficient than the regenerative furnaces as shown below:

EFFICIENCY OBTAINED

No. Furnace	No. 1 Run	No. 2 Run	No. 3 Run	Type of Furnace
2 Mill........	62	63	58	Continuous Recuperalive
5 Mill........	38	41	37	Non Continuous Regenerative
6 Mill........	47	57	53	Continuous Recuperative

This higher efficiency is due to the method of operation of the continuous furnace; namely, the cold steel enters the furnace at one end and progresses slowly toward the other end, at which time it has become hot enough to roll.

The gases traveling in the opposite direction—from the hot to the cold end—are cooled by the steel and therefore leave the furnace chamber at a much lower temperature than the gases of the regenerative furnace. In the latter furnace all parts of the hearth are maintained at the same temperature.

TEMPERATURES OF GASES LEAVING FURNACE CHAMBER

Non-Continuous Regenerative	2001 deg. F.
Continuous Recuperative	1192 deg. F.

The principal heat losses of heating furnaces are the stack losses and radiation. The following table taken from the heat balances secured during the tests shows the relative proportions of these losses and of the heat absorbed by the steel. For the amounts of heat in Btu. refer to Table A, giving data and results of tests:

HEAT BALANCE IN PER CENT

Furnace No.	Type	Per Test No.	Per cent Heat in Fuel Gas	Per cent Heat to Steel	Per cent Heat to Cooling Water	Per cent Heat in Stack	Per Heat Radiated
2	Continuous recuperative ...	1	100	62	1	20	17
2	Continuous recuperative ...	2	100	63	2	21	14
2	Continuous recuperative ...	3	100	58	1	20	21
5	Non-Continuous regenerative	1	100	38	..	27	35
5	Non-Continuous regenerative	2	100	41	..	27	32
5	Non-Continuous regenerative	3	100	37	..	31	32
6	Continuous recuperative ...	1	100	47	2	30	21
6	Continuous recuperative ...	2	100	57	2	28	13
6	Continuous recuperative ...	3	100	53	2	29	16

This table clearly shows the reason why the use of regenerative furnaces should be limited to only those places where it is impossible to apply the continuous recuperative furnace, for less than half of the heat in the gas enters the steel in the non-continuous regenerative type. The regenerative furnace does not lend itself to insulation to prevent radiation, because the temperature over the entire chamber is the same and usually so intense that if insulation were applied the limit of the refractories would be reached and the furnace destroyed. The continuous recuperative furnace, on the other hand, does lend itself to insulation to prevent radiation, because this furnace is comparatively cool and most of the radiating areas can be insulated.

The two continuous furnaces tested had different recuperators as before mentioned. The following table gives the losses in air pressure through the two types:

DROP IN AIR PRESSURE THROUGH RECUPERATORS, IN INCHES OF WATER

Furnace No.	Type of Recuperator	Run No. 1	Run No. 2	Run. No. 3
2	Brick	2.11	2.40	1.55
6	Cast Iron...........	1.18	1.38	1.41

The greater drop in air pressure through the brick recuperator is due mainly to the sharp turns around the ends of the baffles placed in the recuperator. The cast iron recuperator also has a distinct advantage over the brick recuperator in that its passages can be made of such shape and with surfaces smooth enough that the drop in air pressure through it will be less than can be secured in brick recuperators, where the passages in most cases must be made of rectangular cross section and have rough surfaces. Cast iron is also much better for conducting heat than fire brick.

In both series of tests on continuous recuperative furnaces the efficiencies were highest when the largest size billets were handled. The following table gives the size of billets, radiation loss and efficiency for the series of tests on the two recuperative furnaces:

Furnace No.	Test No.	Billet Size in Inches	Per cent Radiation Loss	Per cent Efficiency
2	1	3¼ x 3¼	16.48	62.18
2	2	3¼ x 3¼ and 2½ x 2½	14.54	63.07
2	3	2½ x 2½	20.84	58.29
6	1	2 x 2	20.74	47.30
6	2	2½ x 2½	13.18	57.41
6	3	½ x 2½	16.06	52.52

It will be noted that the series on the smallest size billets had the largest radiation loss. This may be due to improper operation or design. When operating with

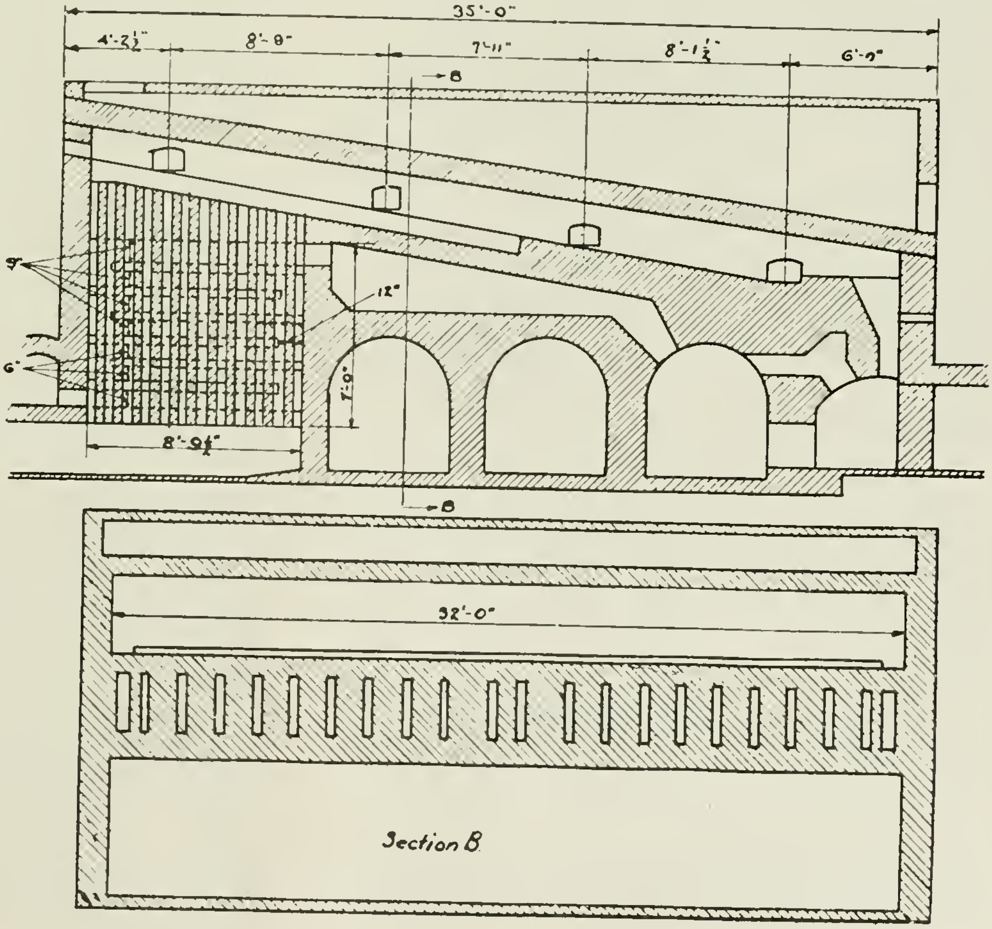

Fig. 4—Continuous Heating Furnace with brick recuperator.

the smaller size, the billets heat more quickly and are at rolling temperature before arriving at the discharging end. This causes a higher average temperature of steel, roof and side walls inside of the furnace, causing the greater radiation loss.

Conclusions and Recommendations: The data here shown was obtained, as mentioned before, on furnaces using by-product coke oven gas as fuel, but the following recommendations for future development will apply in the main to furnaces using any kind of fuel.

From the results shown in these tests, the development of heating furnaces should be along the lines of continuous recuperative furnaces unless some special reason makes it necessary to use another type. As has been shown the recommended type is superior to other types, as it is now built, and can be made even more efficient by development.

The furnace consists of a number of individual units, that is, roof, hearth, skids, burners, pusher, roof recuperator, main recuperator, discharge and charging mechanisms, meters and regulators, insulation and water-cooled devices. These will be taken up independently and recommendations tabulated.

A. Roof. The roof should be placed at such a height above the steel that the gases may wipe both surfaces and yet not cause too much resistance to their flow. A flat roof eliminates the necessity of water-cooling the arch supports. Some method of corrugation may be advisable to increase the surface for absorbing heat from the products of combustion. This would make available more heat for radiation from roof to steel and increase the rate of heat transfer.

B. Hearth. The hearth of the continuous furnace should be sloped from the charging end to the discharging end, care being exercised that the slope is not too great. This applies especially to long furnaces which are to handle large billets. The use of a basic lining for reversing furnaces would give a supply of basic cinder. This can be used in open-hearth furnaces to replace lump ore, and therefore deserves careful consideration.

C. Skids. Solid cast iron skids should be installed on the floor of the furnace, to eliminate the heat lost in cooling-water and to simplify construction.

D. Burners. A series of burners should be installed across the width of the furnace in order to secure a uniform temperature. The burners should be equipped with valves for the independent control of both fuel gas and air for combustion.

E. Regulators and Meters. Each furnace should be equipped with some means whereby the gas and air pressures on the burners may be automatically maintained constant. Each furnace should be equipped with an integrating and recording device which will accurately measure the amount of gas delivered to the furnace.

F. Pusher. A pusher for advancing the steel along the skids of the furnace should be provided which will give a uniform motion that can be regulated very closely, both in regard to distance and speed. This mechanism may be actuated by either a hydraulic cylinder or a reversing motor.

G. Roof Recuperator. The use of a roof recuperator should be limited to that section of the roof in which the refractory property of the brick will not permit it to be insulated.

H. Discharging and Charging Mechanism. The side discharge which was explained in the description of the continuous furnace is superior to the dropping end discharge from a fuel standpoint. It eliminates the loss of heat due to the exposure of a poorly insulated surface to radiation from the hottest zone of the furnace, as it is impossible to properly insulate the swinging door on account of its construction and the abuse it receives. The side discharge admits less cold air to the furnace chamber and a side charging mechanism prevents to a large extent the leakage of air into the furnace.

I. Main Recuperator. The use of metal in recuperator construction has certain advantages over brick. It has a greater heat transfer rate and is not as susceptible to cracking with the consequent air leakage. The possibility of a design with the use of pipes or tubes similar to water tube boilers looks very attractive.

The recuperator should be constructed so that it offers the least resistance to the flow of air and gas consistent with good heat transfer. The gas and air passages should be designed so as to give as nearly uniform velocities at all points as is possible. That is, the variations in the volume of gas and air due to their varying temperature should be considered. It may be advisable to have the air flow through three banks of tubes in series with the waste gases passing over the outside. The tubes should be staggered to give the maximum heat interchange.

The recuperator should be located in such a position that it would be easily accessible for inspection and repair. Placing the recuperator above the furnace instead of under ground should be very carefully considered. A better distribution of the waste gases both through the furnace and in the recuperator would be possible than is the case where the entrance to the recuperator is directly below the steel to be heated, since the gases must pass over the ends of the billets. Additional insulation would be required but no drainage water could collect in the bottom of the chamber or flues.

J. Insulation. Insulation should be used to prevent radiation as far as is possible without reaching the refractory limit of the fire brick and yet remain under the point where first cost would overbalance economy.

K. Water-Cooled Devices. Water-cooled parts should be avoided wherever possible, because they are hard to keep in repair, dissipate an appreciable amount of the total heat of the gas, and their elimination reduces the cost of supplying the cooling water.

L. Waste Heat Boilers. Several installations of waste heat boilers have been made in connection with heating furnaces. However, the development of the recuperator holds such possibilities that furnace efficiencies comparable to good boiler practice should be obtained. Future development, however, may show that in some cases of non-continuous regenerative furnaces the waste heat boiler may have a field.

It will be observed that heating furnaces have been brought to a fair degree of development. The efficiences obtained are not comparable to those of the best heat interchanging appliances, such as boilers and blast furnace hot blast stoves. With the rapidly increasing cost of fuel in this country, it becomes very important that all heat using appliances be made as efficient as possible, and concerted effort along the lines of recuperative furnaces should be productive.

Fluorspar and Its Uses*

A Description of the Mineral—Deposits in the United States and Foreign Countries—Its Uses In and Outside of the Steel Industry—Geological Features, Mining Methods and Equipment—Milling.

By G. H. JONES†

FLUORSPAR, a comparatively unknown non-metallic mineral of moderate cost, widely distributed geologically, but of commercial value only in a few places in the world, is of essential and economic importance to steel makers from the fact that 80 to 85 per cent of the world's production is used in basic open-hearth and electric furnaces as a flux and detergent, and there is no known substitute.

Fluorite, as it is technically known and chemically as calcium fluoride (CaF_2), consists of calcium and fluorine in the proportions of 51.1 and 48.9 respectively. It is of a glassy luster and is only slightly harder than calcite and may be scratched with a knife. It crushes easily and may be distinguished from calcite by its failure to effervesce with dilute hydrochloric acid. It crystallizes in the isometric system and is often found in cubical crystals. Its specific gravity is 3.2 and it weighs approximately 200 pounds per cubic foot. Its cleavage is perfect. Its melting point is about 1,650 deg. F. In color fluorspar ranges, according to purity, from a clear colorless to a slightly bluish glass-like substance through various brilliant shades, and much of it is quite opaque. The color has little significance chemically.

The deposits thus far exploited in the United States are in Arizona, Colorado, Illinois, Kentucky, New Hampshire, New Mexico, Tennessee and Utah. Dependable domestic production based upon existing market conditions can only be obtained by users east of the Missouri River, from the Illinois-Kentucky districts, the great size and purity of which indicate that for many years they will continue to be the main source of our supply. The tonnage may be divided between Illinois and Kentucky as 70 is to 30.

In England fluorspar occurs abundantly in the carboniferous limestone and associated shale of the Yoredale group, where it is found as the gangue of metalliferous veins. It is usually but not invariably associated with calcite, quartz and barytes. The principle producing localities are in Durham and Derbyshire. A large proportion of the fluorspar produced in England has been obtained by screenings from waste dumps from old lead mines. But in the last few years the demand has called for a greater production. Other sources, including mining, are helping to furnish an adequate domestic supply and some tonnage for export.

In Canada there are known deposits in Ontario, but they are negligible from a commercial standpoint and worthy only of passing notice. Some fluorspar is mined near Trail in British Columbia, but now finds a possible market among steel makers only on the Pacific Coast.

Germany has been an exporter for some years of high grade ground fluorspar, and is now prepared to furnish gravel for steel making from several mines, which have been opened under the stimulus of increased domestic demand and the possibility of exporting to the United States and other countries.

In Mexico, flourspar has been found in many places but has been mined commercially in only one, a large deposit located near Guadalcazar, in San Luis Potosi. Other deposits promise to become profitable, and one of green fluorite, in Zacatecas, has been worked to a small extent.

In the United States buyers of fluorspar in Colorado, Utah and the Pacific Coast will continue to secure their supply from the western and foreign producers, as the rates of freight from the Illinois-Kentucky fields are too high for successful competition.

Fluorspar, formerly largely a waste product of the gangue of lead mines and in a smaller amount of other metal mines, was used in smeltnig as long ago as 1529 (Agricola), and according to H. Foster Bain, fluorspar was first discovered in place in Illinois in 1839, when it was encountered in galena in sinking a well on the farm now the property of the Fairview Company. In 1842 spar was discovered in galena near the site of the present Rosiclare mine. From that time on mining appears to have been carried on more or less continuously, but shipments did not begin until the early seventies and since 1880 have been regularly reported. In 1891 only one or two mines were actually making shipments. The production of washed gravel spar commenced in the spring of 1894, although the demand for it by steel companies at that time was small. A limited tonnage of lump spar was produced and shipped four or five years earlier.

Its consumption runs evenly with the production of basic open-hearth steel ingots, and its production increases or decreases as the steel business is good or bad.

The demand for steel making is for a washed gravel, sized ¾-inch and under, of 85 per cent and over in calcium fluoride and not to exceed 5 per cent in silica, and free from sulphides, lead and zinc, the shipper being penalized according to an agreed percentage, varying with different buyers, for a lower calcium fluoride or a higher silica content than the percentages here given.

A properly equipped mine has its own laboratory and watches the analyses as they are made from the mill feed, mill run and car loading, and is therefore in a position to guarantee the user the analysis specified.

This brings to my mind the necessity for buyers to adopt standard specifications for fluorspar and I suggest that this be taken up with the American Society for Testing Materials in order to determine what analysis is best for steel makers and other users, presenting penalties for inferior quality, and a bonus for superior ones, as in the case of iron ore, bearing in mind that the analysis specified should be fair and reasonable and not increase the cost to the seller, or make it so difficult to produce as to lessen the supply.

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*Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

†President, Hillside Fluor Spar Mines, Chicago, Ill.

The open-hearth melter would then know exactly what he had to work with. It is a common assumption that the melter throws in so much spar whether hign or low in calcium fluoride or silica, but that is not the case as he uses only enough to bring about the reaction required, and in that way readily determines the grade employed. There should be no excuse for paying for, and paying freight on unnecessary impurities, and the value of fluorspar to the steel maker should be based upon the amount of calcium fluoride and the lack ot silica at consumers' bins.

Calcite which practically represents the difference between calcium fluoride and silica and 100 per cent is lime, and therefore not injurious, but of some value in the furnace.

The modern fluorspar concentrating mills eliminate all impurities objectionable to the users such as lead, zinc and barium sulphides, and these impurities have only to be considered when buying foreign fluorspar, or that shipped from mines having no separating equipment.

From the heads of the operating departments of a large steel company, I have been given the following information:

The elimination of phosphorus and sulphur depends almost entirely upon the limestone, so in order to take care of the phosphorus and sulphur it is necessary at all times to have a highly basic fluid slag. Phosphorus is reduced at a low temperature while sulphur is reduced at a high temperature. In fact, most of the sulphur is reduced after the heat has been melted and the slag made fluid and the bath raised to higher temperature.

The limestone slag, immediately after the heat is melted, lies like a blanket upon the bath and to insure proper oxidizing conditions it is necessary to thin up the slag, and render it more fluid so that the metallic contents of the bath will come into more intimate contact with the oxidizing slag. It is the universal practice in this country to use fluorspar for this purpose. Fluorspar acts as a neutral reagent and does not affect the basicity of the slag. The increased fluidity not only allows for quicker elimination of impurities in the metal but allows the transference of heat from the fuel to the bath of metal in much quicker time.

Twenty years or more ago it was the general practice in most of the steel plants of this country to add fluorspar just before the furnace was ready for tapping. During later years, however, it has become the more general practice to add the fluorspar in the early stages of the working of the heat, not only to allow the slag time enough to function properly with regard to impurities in the metal, but to eliminate sulphur at higher temperature and to allow the furnaceman more opportunity to quickly raise the temperature of the bath in case it is necessary to tap the heat a little early.

In some steel making districts, particularly in the east, pig iron is apt to be high in phosphorus and low in manganese and it is the general practice where scrap is plentiful and cheap, to charge as little pig as possible. Iron of this character requires a high lime charge, due to the fact that the small pig iron charge with consequent decreased amount of silicon and manganese does not tend to create a fluid slag; therefore, large additions of fluorspar are necessary. High manganese pig iron increases the fluidity of the slag and, therefore, decreases the amount of fluorspar necessary for thinning out the slag. A low silica content in fluorspar is most desirable as a high silica content means additional limestone. The latter item is not desirable from a tonnage standpoint because a high limestone charge adds to the time of heat in the furnace with the subsequent reduction of tonnage.

The general practice in this country would indicate the average consumption of from eight to 10 pounds of fluorspar per ton of steel. This depends upon the character of pig iron, scrap, etc., used in the various districts. The use of alumina as a substitute for fluorspar is being advocated in some quarters but to date has not been proved up commercially.

No bad effects of the spar on the walls or roof of the open-hearth furnace have been known and it has been found as time goes on that open-hearth superintendents are increasing the amount of flourspar used per ton of steel melted.

Mr. H. M. Howe in "The Metallurgy of Steel" (1890) in summing up fluorspar says it appears to favor dephosphorization:

1. By liquifying the slag and enabling it to assimilate the lime present, part of which might otherwise remain unmolten and inert and thus rendering the slag effectively basic to it.

2. Probably by volatilizing silicon from the metal thus diminishing the formation of silica and thereby increasing the basicity of the slag.

3. In certain cases, for example, when the conditions are not strongly oxidizing, by volatilizing phosphorus as fluoride.

Dr. Richard Moldenke at the New York Institute meeting, February 19, 1922, claimed that basic hearth electric furnaces should be used in every new installation. To desulphurize rapidly and well, lime and fluorspar must be used in combination to form an active slag on the molten metal.

The Iron Age, April 6, 1922, under the heading of "Fluorspar in the Open-Hearth" reviews editorially an article from a German source previously printed in The Iron Age of March 23, 1922 to which I refer you, as follows:

"New light is thrown on the chemistry of basic open-hearth practice by an article from a German source in The Iron Age of March 23 on 'Fluorspar in Open-Hearth Practice.' It is important to American steel makers in view of the large tonnage of basic open-hearth steel made in this country. Fluorspar is used in almost every heat of such steel, but the common thinking as to its function has not gone beyond the thinning of the slag and the cutting of the lime.

"The German studies show that fluorspar does more than this. It is an effective agent, when properly used, in removing sulphur from the steel. Comparing nine heats without fluorspar and nine in which it was used, the writer shows that in the first set, with all other conditions the same, the average sulphur content of the finished steel was 0.08 per cent and in the second set sulphur was down to 0.05 per cent. The author controverts the theory that the desulphurization, when fluorspar is used, is brought about by the slag being thus rendered more basic, and he shows by actual results that the ratio of the oxygen of the bases to that of the acids was 1.7 without fluorspar and 1.30 when fluorspar was used, there being in the latter case a marked decrease in sulphur in the steel. The presence of too much sulphur in basic steel has been a matter of no small concern in this country, it being more difficult to remove this element than to remove phosphorus in basic practice."

Outside of the steel industry many uses, and growing ones, are found for fluorspar. The glass, ceramic and enameling trades, including enameled tile and brick, are the next largest users, and use the highest grade hand picked and ground spar. Then come perhaps the electrolytical smelting of lead and antimony and other non-ferrous and ferrous smelters. It is also commencing to regain the standing it once had among foundries, the demand from which is expected to steadily increase, as the benefits derived include the reduction of the coke necessary on account of the reduction of the number of pounds of fluxing material used. Cleaner castings are obtained on account of more fluid metal and greater freedom from slag, and stronger castings for the same reason. Less iron is lost in the slag and the slag is more liquid. Less work is required in cleaning and repairing the cupola and taking care of the dump, by reason of the liquid slag causing the cupola to clean itself more readily, and because this class of slag is brittle and hence breaks up more readily in cleaning away the dump.

Fluorspar is also the main component part of many special foundry fluxes. It is used in the manufacture of carbide; in the preparation of a cyanide for the extraction of gold; in the mixing of certain cement waterproofing compounds; in a limited way by some Portland cement manufacturers; by chemical works in the manufacture of hydrofluoric acid, and sodium fluoride, practically chemically pure spar being specified. Also in the extraction of aluminum from bauxite.

A word about sodium fluoride for preserving wood. Mr. George M. Hunt in charge of section of Wood Preservative Forest Products Laboratory of the United States Government writes: "The desirability of sodium fluoride as a wood preservative is practically established. One large coal mining company has been using sodium fluoride since 1915 for the treatment of its mine timbers in preference to either coal tar, creosote or zinc chloride.

The present consumption of zinc chloride for wood preservation is about 25,000 tons per year, and the use of creosote is somewhat in excess of this.

Sodium fluoride can be used in the same manner with the same apparatus and for the same wood preserving purposes as zinc chloride. Sodium fluoride is twice as toxic as zinc chloride, is much less corrosive, does not injure paint, can be shipped as a dry powder in slack cooperage, and if it were in adequate supply at a reasonable price could eventually largely supersede zinc chloride, and probably creosote to a great extent.

Wood treated with sodium fluoride is non-inflammable, hard to ignite, burning poorly, and easily extinguished. This is practically the same as with zinc chloride, whereas creosote burns freely with a black smoke.

Several European countries and especially Austria, are making extensive use of sodium fluoride in preservation of all kinds of wood work, such as warehouses, dwellings and other building construction. It is also used more or less as an insecticide.

Mr. Benedict Crowell in the Engineering and Mining Journal, January 21, 1922, made the statement which follows: It is not generally realized that the known fluorspar deposits of this country are very limited in extent. War stimulation failed to develop a single new ore body of consequence, that I know of. The increased supply in 1917 and 1918 came from the exhaustion of reserves at the principal mines, depletion of all old and newly located shallow deposits, working over old dumps, and salvaging the low grade ore left in the old workings of abandoned mines. Prices of $35 to $60 per ton justified extreme activity.

Only four producers in the Illinois-Kentucky district have railroad connections. The rest are compelled to haul the ore and supplies from four to 15 miles over dirt roads, that are almost impassable for five months of the year.

During the war period many new companies were organized to develop and operate fluorspar prospects. Practically all used up their capital and passed into history. Many of them never actually produced a car of ore.

Exhaustion of shallow deposits, the uncertainty and added cost of deeper mining, necessary exploration, and dead work are contributing factors which have tripled the cost of producing fluorspar. It has become a complicated, expensive and relatively deep mining proposition.

Mr. J. M. Blayney, president of the Fairview Fluorspar and Lead Company in The Iron Trade Review, February 9, 1922, says: "The fluorspar industry today bears little resemblance to that existing six years ago. Few branches of business have so changed in such a short span of years, and probably in no other does the consumer know so little about the source of supply.

"In the earlier years the smaller demand was easily satisfied principally by a few operators favorably located on the Rosiclare vein in Hardin county who were mining comparatively large bodies at shallow levels and at low cost. In those days the shaft was small, the equipment was crude, and the milling plants were easily and inexpensively constructed. The ore bodies were relatively wide and the ore was of good quality, carrying little waste. The milling methods were simple and labor was cheap.

"Of all the operations in the Kentucky field, only one producing mine has a railroad connection. Most of the others lie from three to 14 miles from the shipping point, and the mine product and supplies must be hauled by team over dirt roads wholly impassable for such use about five months of each year.

"It is the consensus of opinion of mining engineers familiar with the industry that fluorspar deposits cannot be determined with any reasonable assurance except by the sinking of shafts and the driving of drifts. Diamond drilling is practically useless for the purpose of blocking out ore bodies. This is due, first, to the frequent pinches, both lateral and perpendicular, and to the rapidly changing widths and erratic character of the deposits themselves. In the second place, the Rosiclare district is largely honeycombed with narrow fissures or slips containing fluorspar from a few inches to a foot in width, lying at various angles and wholly unconnected with any commercial deposits of fluorspar, rendering the reading of core results uncertain. Diamond drilling has been tried for many years in the district by half a dozen different companies, but no commercial body of fluorspar has even been developed by its use. Expensive shafts have been sunk on the apparent indications of diamond drill cores and in each case have failed to develop ore bodies."

Production of fluorspar in the United States was first reported in 1883. Years of normal production are:

1883	4,000 tons
1892	12,250 tons
1900	18,450 tons
1905	57,385 tons
1910	69,427 tons
1915	136,941 tons
1920	186,778 tons

The largest shipments, due to previous war demands, were 263,817 tons in 1918 to which add 12,572 tons imported in that year.

In 1921 shipments dropped to 34,960 tons due to large stocks and depression in the steel business.

English production has averaged for the last eight years about 50,000 tons annually. Exact German production reports are not available, but indicate about 8,000 tons annually, and should show much larger for 1921 and 1922.

The highest average prices realized for fluorspar at mines including shipments made on old low-price contracts were:

1918	$20.72 per ton
1919	25.49 per ton
1920	25.26 per ton

Basic open-hearth steel production at five-year intervals shows:

1900	2,545,091 tons
1905	7,815,728 tons
1910	15,292,329 tons
1915	22,308,725 tons
1920	31,375,723 tons

As indicating the consumption of fluorspar for these years gravel fluorspar was produced in the United States as follows:

1910	52,013 tons
1915	114,151 tons
1920	154,786 tons

No records were kept of importations when fluorspar was on the free list, prior to August, 1909, but for subsequent years imports were as follows:

1910	42,488 tons (largest on record)
1915	7,167 tons
1920	24,612 tons

Of the 1920 imports England furnished 17,096 tons, Canada, 7,086 tons, chiefly from British Columbia, and Germany, 407 tons.

Fluorspar was on the free list until August, 1909, when a duty of $3.00 per ton went into effect. This was reduced to $1.50 per ton, October, 1913. The present duty of $5.60 per ton is in the new tariff of September, 1922.

Shipments are made in open or box cars, in bulk or in 125-pound bags or barrels, and in less than carloads in these packages.

A rough estimate shows consumption about as follows:

Steel ingots and castings	80 to 85%
Glass and enameling	7½ to 10%
Hydrofluoric acid	5 to 6%
Foundries	1 to 2%
Miscellaneous	2%

Geological Features.

The Illinois State Geological Survey (Bulletin No. 41, 1920) in co-operation with the United States Geological Survey has made a careful study of the geology of the fluorspar region in Illinois and has issued a very interesting and complete report covering its field work.

The rock formation consists of limestone, shales and sandstones of Devonian, Mississippian and Pennsylvanian age with massive limestone beds predominating, the uppermost series of these beds underlying the coal measures, dipping under them to the north and west.

Structurally the geology is very interesting as the rock beds have been bowed up to form an immense dome. The intrusion of igneous dikes and sills caused further rock movements and adjustments with differential settings of large blocks and the formation of large fissures and faults. These faults, planes and fissures furnished channels in which ore-bearing solutions traversed the strata and where conditions were favorable filled up the fissures with ore deposits containing fluorite, lead and zinc, with a calcite gangue. Not all fissures contain ore nor are all ore deposits in fissures, but it seems well established that the ore-bearing solutions used the fissures as channels for circulation.

The first mineral to be deposited in the fissures was calcite, and later changes in the character of the circulating waters and often a further series of rock movements caused the calcite to be redissolved and replaced by fluorite accompanied by lead and sometimes zinc.

As is often the case in many mining districts, there is in the Illinois fluorspar district, one especially notable vein or fissure system. This unusual vertical fissure vein is known as the Rosiclare vein which, with several parallel veins formed at the same time, has produced nearly all the fluorspar mined in Illinois. This vein has been traced for a length of nearly three miles and the underground workings on it total some 10,000 feet in length and it has been developed to a depth of 620 feet from the surface. The dip of this vein is to the west, but it is so slight as to be practically vertical.

The ore chutes on this fissure attain a maximum known width of about 22 feet with an average width of 6 to 8 feet. There are narrow spots or pinches alternating with good sized bodies of ore, as is usual in most fissure veins, and some ore chutes have been mined that measured over 1,000 feet long.

There is one fluorspar deposit, located near Cave-in-Rock, Illinois, which is unusual in that the fluorite has replaced a bed of limestone. Apparently the mineral-bearing waters circulated through the fissure which was closed by a bed of shale overlying a soft permeable limestone which has been replaced by fluorspar. In places this deposit is workable and several mining operations have been conducted on this bed which outcrops on the side of a hill, making open cut work feasible for moderate distances followed by underground mining from adits.

Three companies operate on the Rosiclare vein, namely the Rosiclare Lead and Fluor Spar Mining Company, The Fairview Fluorspar and Lead Company, and the Hillside Fluor Spar Mines.

Mining Methods.

The usual methods of developing the fluorspar deposits in the fissure veins is by means of vertical shafts and drifts in the ore at vertical intervals of 75 to 100 feet. The larger mines put down a three-compartment concreted shaft with two compartments for cages or skips and a pipe and ladder compartment. When in ore it is customary to drive the drifts the full width of the ore and 12 to 14 feet high so that the necessary head room for setting timbers is secured.

Hitches are cut in the foot wall and heavy stulls are set across to the hanging wall, spaced about six-feet centers, the head of the stull being several feet higher than the foot, depending upon the width of the drift. These stulls are usually set with the heel or hitch end about five feet above the tram tracks and chutes for drawing ore are then built between alternate pairs of stulls.

The stulls are then covered with poles or split lagging and stoping begins by shooting down the ore upon the timbers and drawing it off through chutes into the tram cars. Enough ore for the miners to stand on and reach the back is held in the stopes, so that when a stope is beaten out to the level above it is practically full of broken ore, which amounts to about one-half of the ore originally in place in the solid.

Mine Equipment.

As none of the fluorspar mines are over 650 feet deep the hoisting equipment required is not large.

Sinking is done with the jackhammer type of drill, drifting and crosscutting is generally done with a mounted type machine, sometimes with a jackhammer where the ground is not too hard and a Waugh turbo type where more power is needed. Stoping is all done with air feed hand rotated stoping machines.

Pumping equipment is of great importance as the mines are wet. Under normal conditions the Fairview Company pumps about 1,500 gallons per minute and the Rosiclare Company about 700 gallons per minute, but in times of high water in the Ohio River the flow of water increases to double these figures.

Both of these mines are deeper than the Hillside mine which is mining in drained territory and has no water to speak of.

Milling.

To produce the commercial grades of spar demanded by the market it is necessary to mill the run of mine ore.

The Bureau of Mines has completed its fluorspar investigation of this year and says: "The importance of fluorspar in the steel and ceramic industries is so great and accurate information on methods of mining, milling and utilization, and on costs of production of fluorspar is so lacking that it has been considered advisable by the Bureau of Mines to investigate all phases of the fluorspar industry in the United States. At the request of and in company with several Eastern fluorspar producers, examination has been made of the principal fluorspar deposits of the Western States. This examination was followed by an intensive study of the producing mines in Illinois and Kentucky. It was found that most of the deposits of the far Western States were small and could not be relied on to produce such surplus over the needs of the Western States. Costs of production in the Illinois-Kentucky field have increased greatly owing to the increasing depth of the principal mines, the large amount of water that must be pumped and the increased cost of labor and supplies. A report of all phases of the fluorspar industry is in preparation."

Notwithstanding the large existing demand for fluorspar under normal conditions, which is constantly increasing, owing to the general increase in business and from new uses found for it, I feel it is not necessary that a substitute should be found, as with an increase in price, old mines and prospects in the Illinois-Kentucky field would be worked again as soon as a market price justified.

The same condition would again bring spar to the Eastern users from Colorado and New Mexico and importations from England and Germany would make up the deficiency, if any.

At succeeding levels of higher prices more and more production would come in until the demand was satisfied. An advance of a few or several dollars per ton would not be burdensome. Five dollars per ton would not be burdensome. Five dollars per ton would mean only 2½ cents per ton additional cost for steel ingots.

I think I am justified in saying that if necessary to insure an adequate supply the leading miners of florspar, if approached in the right spirit, with their knowledge of mining, with ample capital and expert engineering departments, would undertake necessary development work in the outlying districts provided the owners of prospects or local capital could not do so.

ALUMINUM INVESTIGATIONS OF THE BUREAN OF MINES

The investigation of cracks in aluminum alloy castings, conducted by Robert J. Anderson, metallurgist at the Pittsburgh, Pa., experiment station of the Bureau of Mines, has been finished in part, and a preliminary report issued. A method has been devised for the direct determination of aluminum in aluminum and aluminum alloys and also for aluminum oxide in these materials, and a report was issued.

SYNTHETIC CAST IRON

As is well known, pig iron is not produced on the Pacific Coast at the present time in sufficient quantities to meet the demand for iron of such grades as are required for foundry purposes. As a result, foundry iron is costly, due to high freight rates on eastern iron that is brought in and to the high cost of coke suitable for use in the cupola. On the other hand, considerable steel scrap is to be had, and, for that reason, attention has been recently given by the members of the Electrometallurgical Section of the Northwest Station of the Bureau of Mines at Seattle, to the problem of determining the best conditions for the production of cast iron by melting scrap steel in the electric furnace. These conditions were established by numerous experiments conducted in a laboratory furnace holding 300 lbs. of metal.

Later on these conditions were applied in a local foundry with excellent results. Low-grade miscellaneous steel scrap was melted and carburized in a 3,000-lb., direct arc, 3-phase electric furnace and the resultant metal discharged into the pouring ladle and then into the molds for the miscellaneous grey iron castings which made up the normal output of the foundry. The carbon and silicon content of the product was under control at all times and the furnace operator had no difficulty in producing the grade of iron required. Satisfactory castings were made with the normal consumption of power and electrodes.

Bases of Modern Blast Furnace Practice

Outline of Bases Upon Which Modern Blast Furnace Practice Has Been Built Up—Shows How Adoption of These Methods Leads to a Desirable Improvement Both Regarding Economy and Output.

By A. K. REESE*

PART II

IN the sense in which furnace design bears upon the purpose of this paper it refers not to the structural detail of the furnace as a whole, but to that portion only in which the metallurgical operations take place; that is, the furnace proper, the interior space, the design of which is technically known as the "lines of the furnace."

The terms usually used to describe the lines of a blast furnace divide it into a number of sections. namely, the hearth or crucible, which is cylindrical; the bosh, an inverted truncated cone; the shaft, an upright truncated cone; and the throat—in modern furnaces usually cylindrical—extending from the top of the shaft to the top of the furnace.

The principal dimensions of these sections consist of heights, diameters, the acute angle of the bosh wall to the horizontal, and the batter of the shaft wall to the vertical. Each of these dimensions has a very important bearing upon all the others, and their relation to each other is of the first importance as a factor in modern blast furnace practice; for although they may vary somewhat in their relation, the variations are limited to conform to certain principles, the height of the furnace and hearth diameter being the dimensions which control all the others.

Under this heading—Furnace Design—the author proposes to outline and discuss these principles, and to enunciate as a general law the principle that *the output capacity of a blast furnace (with any particular set of raw materials) is in proportion to the effective bosh area.* The nucleus of this law is the word *effective*, for as will be later shown the maximum effective bosh area is dependent upon the various factors which constitute the principles of modern blast furnace practice.

Modern development in blast furnace design has established the following essentials. A shaft batter of 1 in 13.5 to 15, the low bosh, the large hearth diameter, and the deep bosh angle—all of which are, of course, comparative terms in their relation to similar features in the older designs.

In a figure showing two furnaces, "A" and "B" of premodern lines (extreme cases have been chosen in order to emphasize the principles under discussion), and showing two furnaces, "C" and "D" of modern lines, the tendency is further to increase the hearth diameter, and a furnace is now in successful operation with a hearth diameter of 20 ft. 9 in., but in this direction it is sufficient for the present purpose to avoid the extremes.

Throat and Stack.—The upper section of the furnace or throat is, as above mentioned, usually cylindrical in shape and extends to from 20 ft. to 25 ft. below the furnace top or 12 ft. to 17 ft. below the stock line, the highest point to which the furnace may be filled. The adoption of the cylindrical throat is primarily in order to obtain the desired batter to the shaft walls, although it also has a bearing upon regularity of distribution by presenting to the charged materials an area of the same dimensions for the varying positions of the materials in the throat due to their constant movement. The latter point, however, is not of great importance in the modern furnace plant as the charging appliances are usually, or should be, of ample capacity to keep the furnace fully charged at the highest rate of driving.

Within the distance to which the cylindrical throat extends the condition of the materials is such that there is no tendency for them to adhere to the walls or to hang through jamming, or arching, as they are in a "dry" condition, both as to moisture and pastiness, and their expansion through increase in temperature is not yet sufficient to require increased space for their accommodation so as to avoid the danger of restricting free movement. Below this point, however, temperature increase becomes much more rapid and reactions much more intense. In this alteration in condition and temperature, which is progressive as the materials descend, more space accommodation is required for free movement, more particularly because to expansion is added the semi-pasty condition, and the increased density of the mass through the increasing load bearing down upon it from the increasing weight of superimposed materials. It is also probable that the question of carbon deposition enters into the necessity of greater space accommodation as the materials descend into the hotter and more active regions of the furnace. Hence the necessity for the expanding batter to the shaft walls. It would also seem obvious that the more rapid the descent of the materials into and through these zones (faster driving), the greater must be the increase in space accommodation. In the older furnace designs, with slower driving, shaft batters as low as 1 in 26, and possibly less, were in use. In modern practice it has been found necessary to increase this batter to 1 in 14, or thereabouts. The principles involved in this feature of modern blast furnace design are of the greatest importance, and probably explain, in part at least, why many furnace managers have failed in their attempts to apply fast driving to furnaces with lower shaft batter.

To revert for a moment to throat diameter, there are in this feature several opposing conditions to consider. The lower the velocity of the gases as they leave the furnace top, the lower the loss from flue dust carried over with them. The largest possible throat diameter is, therefore, desirable for this reason. On the other hand, the extent to which this feature may be provided for is limited by the question of distribution, both of the materials charged into the top and the ascending gases, as regards the most uniform action of the latter over the whole cross-section of the former. The throat diameter is also limited by the required shaft batter, and the bosh diameter and height. Sacrifices must, therefore, be made in one direction or the other, and as the question of losses by flue dust is largely affected by regularity of stock movement, features tending to the latter should have first consideration. Throat diameters are, therefore, restricted in modern furnaces of 85 to 95 feet in height to from 15 to 17 feet, the controlling factors being the other dimensions such as hearth diameter, bosh diameter, and height.

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The Low Bosh.—The low bosh was the direct outcome of attempts to increase blast furnace outputs by increasing the volume of blast blown per minute. These attempts with the old high bosh furnaces resulted in seriously increased furnace irregularities, the reason for which became apparent from the study of the altered conditions brought about in the furnace through the more rapid driving, and the troubles experienced. With the much more rapidly descending materials it was found necessary that the contracting part of the furnace, that is, the top of the bosh, should begin below the upper limit of the zone of fusion in order to prevent the pasty materials just above the zone of fusion entering the contracting area, where they would be subjected to a squeezing action as a result of the resistance of the bosh walls, and the weight of the superimposed materials, with the consequent tendency to pack and cause hanging and the formation of scaffolds on the upper bosh walls.

The continued lowering of the top of the bosh followed therefore the continued attempts at faster rates of driving for larger outputs, until in modern practice a bosh height for 85 to 95 ft. furnaces, of 10 to 12 ft. above the top of the crucible, has been adopted as compared with as much as 30 ft. in the old design. While it is true that no one would build a furnace with a 30-ft. high bosh today, there are furnaces in operation of recent design with boshes 16 to 18 ft. or even higher. Any attempt to rapidly drive such furnaces is sure to result in increased irregularity and consequent failure. The basis of this principle—the low bosh—is, therefore, that the furnace be so designed, as regards bosh height, that the expanding portion of the furnace, that is, the shaft, shall continue to a point slightly below the beginning of the melting zone, so that no pasty materials shall enter the contracting portion at the top of the bosh. In actual practice many, in fact most, modern furnaces are designed with a cylindrical section from 5 to 8 ft. in height between the lower limit of the expanding shaft and the upper limit of the contracting bosh. This section has no justification from the standpoint of any principles involved in its adoption, except that it fills up with brickwork the angular space at the junction of the bosh and shaft, which to a degree may be considered "dead space," and renders less abrupt the transition from the expanding shaft to the contracting bosh, but is rather the result of necessity in order to obtain the desired relation between other features such as shaft batter, throat diameter, and bosh diameter height.

The bosh diameters, for what may be called full-sized blast furnaces, that is from 85 to 95 ft. high, are usually from 20 to 23 ft. with a bosh angle of about 80 deg., while in pre-modern design this angle was anything from 68 deg. or less to 74 deg. The latter feature is the result of the progressive increase in hearth diameters, and, as the author will endeavor to show further on, these two features, the steep bosh angle and the large hearth, are concomitant, and their evolution the result of efforts to overcome irregularities through the failure of earlier designs (with the flatter bosh and smaller open hearth diameter) to bring into operation the maximum effective bosh area, which is, of course, the full bosh area.

The Hearth or Crucible.—In the modern full-sized furnaces hearth diameters are normally from 16 to 18 ft., although, as has already been mentioned, in one instance this dimension has reached 20 ft. 9 in. At present, however, the latter may be taken as an extreme, and it remains to be seen whether hearths of this size are likely to be generally adopted. In the process of evolutionary experiment it is often necessary to overreach the maximum in order to ascertain what it really is.

The hearth diameter of a blast furnace would seem, at first sight, to be the determining factor for its output capacity, and, in the sense that it is the starting point in the design, and, with the bosh angle and bosh height now generally adopted in modern design, practically determines the bosh diameter, it is so, but in the sense that the hearth diameter, together with the low bosh and steep bosh angle, are merely means for making effective the maximum bosh area it is not really the determining factor, which is the bosh diameter. The hearth, or more properly the crucible, is the receptacle for receiving and storing from cast to cast the molten materials, while the bosh area is the active area in which the molten materials are produced as such, and the proportion of that area which is in active operation is the determining factor as to the quantity of molten materials available for collection in the crucible.

In all previous references to the various dimensions of the modern blast furnace, and the principles which have led to their adoption, it is, of course, assumed that in the operation of the furnace the volume of blast is in keeping with the size of the furnace, and is such as will provide the operating conditions upon which those principles are based. In modern practice the volume of blast blown is normally from 40,000 to 50,000 cu. ft. of free air per minute delivered from engines capable of delivering these volumes against pressures, or rather resistances, up to 25 or 30 lbs. per sq. in., to provide ample reserve power for conditions causing abnormally high pressures. Normal working pressures are usually between 15 and 20 lbs.

Effective Bosh Area.—This term, used several times in the foregoing, is, the author believes, a new one in blast furnace nomenclature, but it is one which has a meaning of the first importance in blast furnace operations.

Heretofore it was enunciated as a general law that "the output capacity of a blast furnace, with any particular set of raw materials, is in proportion to its *effective* bosh area."

Before discussing this proposition it is necessary to define:

1. What is the "effective bosh area"? and to consider

2. What are the factors which control or determine the effective bosh area?

3. What bearing have these factors (through their determination of the effective bosh area) upon the output capacity of the furnace?

1. The effective bosh area is that portion of the full horizontal bosh area at its maximum diameter which is in normal activity under the conditions of operation of the furnace.

2. The factors which control or determine the effective bosh area are those which are under discussion in this paper, namely, the condition of the materials charged, the furnace lines, and the volume of blast blown per minute in relation to the size of the furnace.

3. The bearing these factors have upon the output capacity of the furnace is that they determine the area of activity in the melting zone.

The whole trend of evolution in blast furnace practice has been in attempts to devise means of increasing output capacity consistent, of course, with quality and economy, and the degree to which these attempts have been successful in modern practice has been due to the influence the factors in that practice, as described in this paper, have had in increasing the ratio of effective bosh area to the maximum or designed bosh area of the furnace, or to put it in simple terms, *to keeping the walls clean*. It is, therefore, conversely true that the effective bosh area of blast furnaces, where the factors upon which modern practice is based have not been adopted, or which are not operated in conformity with its principles, is less than the maximum or designed bosh area.

As has been described under Preparation of Materials, the direct tendency of lack of such preparation is towards restriction of active area in the furnace. Under furnace design the tendency of the high bosh and the low stack batter is shown to be towards restriction of active area in the furnace. Equally the tendency of the small hearth and flat bosh angle is towards restriction of effective bosh area, owing to the removal of the area at and adjacent to the top of the bosh near the walls too far horizontally from the upward moving gases, with the consequent tendency for accumulation of torpid or stationary materials in that area.

As previously described, for a furnace of a given size, insufficient blast volume to ensure equal activity throughout the whole cross-section at every altitude tends to the production of inactive areas owing to the impossibility of providing perfect uniformity of materials. The greater this lack of uniformity, the greater this tendency. The under blowing of a blast furnace is one of the most fruitful causes of reduction of effective bosh area, with outputs far below maximum output capacity.

The tendency of a blast furnace is to adjust its active areas to the volume of blast supplied to it. This tendency is in strong evidence where furnaces which have been blown for a considerable period with comparatively small blast volume, have been suddenly and too quickly supplied with a considerably increased volume. Operators who have made this experiment will doubtless recall the difficulties they have experienced through irregular working. The author knows of cases where, although the furnace size was quite suitable to the increased blast volume, the attempt has been abandoned through the conclusion that conditions were not suitable to faster driving, whereas a little persistence would probably have overcome the difficulties met with by the walls gradually clearing, and then furnace thus adjusting itself to the larger volume.

It is, of course, true that many blast furnaces in operation today are not adaptable to modern practice in its fullest sense. One or more of the necessary factors are lacking, and, as the author has attempted to show, each of these factors is so dependent upon the others that they must all be present for its full application. Among them, however, there is one, preparation of materials, which, if adopted alone, would provide conditions which would render possible the partial application of others with decided improvement in results, and tend to remove many of the difficulties now experienced.

Auxiliary Equipment.

Under this heading it is not intended to enter into, nor does the purpose of this paper call for, a detailed discussion of the many units comprising the auxiliary equipment of a modern blast furnace. There are, of course, certain units which are essential to the operation of any blast furnace. Where, for the purpose of emphasizing the requirements of modern blast furnace practice, it is necessary to discuss the modern features of these units they will be specifically referred to. There are also certain units which, while not essential to blast furnace operation in general, are essentials, from the standpoint of economical operation, to modern practice. These will be discussed in more detail, but only so far as the principles involved in their adoption are concerned.

The auxiliary equipment, or plant required for the operation of a blast furnace, may be divided into four sections:

1. The Power Plant.
2. The Blast Heating Plant.
3. The Raw Material Supply Plant.
4. The Output Disposal Plant.

Equipment falling under one or other of these sections is essential to the operation of every blast furnace (excepting, of course, a cold blast furnace which need not be considered here). In modern practice, however, there are certain features in the details of the plant required, bearing upon the method and economy of operation, which are essential to the full adoption of that practice.

1. The term *Power Plant,* which is used here in its most comprehensive sense, covers all apparatus for producing and utilizing the power required for sustaining the blast furnace operations. The principal among these are the boiler plant, the blowing engine plant, the electric generating plant, the water-pumping plant, and, in some cases, the hydraulic power and compressed air plant(and it might be added the dry blast plant). With regard to most of these items, it need only be said that they should be of the most modern, simple, and economical type, with ample reserve of power and capacity, in order to minimize those costly furnace stoppages which are otherwise likely to occur through mechanical failures, or interference with normal operation through lack of efficiency. In other respects they do not, with the exception of the blowing engines, bear directly upon the principles of modern blast furnace practice. In regard to blowing-engine capacity, and—in one particular feature—to turbo blowers, there is a point which it is important to emphasize. As previously stated, the volume of air required for the normal operation of a full-sized modern blast furnace is from 40,000 to 50,000 cubic feet of air per minute. It is important that this air should be delivered in as continuous a flow—that is as free from pulsations—as possible.

With reciprocating engines, the speed and number of blowing cylinders should be as great as possible consistent with engine safety and efficiency, and the range of volume delivered, with a fair degree of economy, as wide as possible. The engine should also be designed to deliver their maximum volume against pressures up to 25 to 30 lbs. per square inch with steam pressure or gas of quality at least 20 per cent below the normal, in order to provide for those abnormal conditions to which every blast furnace is liable. As regularity in air volume delivery is an essential of modern blast furnace practice, every blowing engine should be equipped with an efficient governing device.

As above mentioned, the centrifugal or turbo blower is widely used, and is rapidly growing in favor for blast furnace work. Well designed blowers of this type have a number of advantages over the reciprocating type. They are simpler in design. Per unit of capacity they are lighter in weight, require less floor space, less massive foundations, and are lower in first cost. They have fewer moving parts, have no losses through reversal of motion, are lower in cost of maintenance and repairs, require less attention in operation, and are much easier and less costly to lubricate. They have the advantage of giving a continuous flow of blast delivery, being entirely free from the pulsations in delivery, within their rated capacity, characteristic of the reciprocating type. There is however one feature in the turbo blower as compared with the reciprocating blower which must be specially provided for to ensure its suitability for modern blast furnace practice. As above stated, regularity or constancy of the volume of free air per minute, required by the furnace operator for the time being, is an essential of that practice. This volume must not materially vary or be affected by the more or less varying resistance, commonly called pressure, on the delivery side of the blower, due to the varying furnace conditions. In reciprocating blowers this requirement offers no difficulty, as regularity of the volume delivered is assured by regularity in engine revolutions, whatever the resistance, within the limits of the capacity of the blower. In the turbo blower, however, the volume delivered varies both with the engine revolutions and the resistance on the delivery side. The turbo blower, therefore, requires for its satisfactory application to modern blast furnace practice a special type of governing or controlling device in order to assure the delivery of a constant volume of blast per minute against the varying resistance offered by the varying furnace conditions, that is, a volume controller. For many years this feature in the turbo blower was a serious drawback, notwithstanding its many other advantages, to its adoption for blast furnaces. Its general adoption and growing use in recent years is directly due to this difficulty having been successfully solved through the design and application of an efficient volume regulator.

2. *The Blast Heating Plant* consists essentially of the hot blast stoves and their connections, for receiving cold blast from the blowers and waste gases from the furnace, and for delivering hot blast to the furnace and consumed gases to the atmosphere. Under this heading should be included another installation which, while not essential to blast furnace operation in general, is from the standpoint of economy an essential part of modern blast furnace equipment. This is the gas cleaning plant, or rather, a rough gas cleaning plant as distinct from the plant required for the high degree of gas cleaning necessary for use in gas engines.

The advantages and economies obtainable by the use of clean gas as compared with uncleaned gas are many and of very considerable importance, and far outweigh the cost of installation, operation, and upkeep, etc

Though this question has already been fully discussed by various writers, a number of these advantages, some of which also apply to the boiler plant, are enumerated as follows:

(1) A much higher thermal efficiency of the gas is obtained through more perfect combustion, by better control of air and gas mixture, and the elimination of fume and other heat absorbing solid matter, with the consequent increase in the heat units available for absorption by the stove checker bricks and boiler flues.

(2) The saving of the labor constantly required for cleaning stoves and boiler flues.

(3) The saving of labor and materials required for repairs to stoves necessitated by the fluxing effect of the solid matter in uncleaned gas on the brickwork.

(4) The much longer life of stove linings through the absence of these destructive effects of uncleaned gas.

(5) The much greater time service per stove—and per boiler—through the elimination of lost time for cleaning and repairs.

(6) The much greater possible heating surface per unit of stove volume through the use of smaller checker openings, and the higher efficiency thus obtainable.

(7) The greater regularity in blast furnace temperatures obtainable through the maintenance of a higher average stove efficiency.

(8) The hot blast being practically free from abrasive dust there is an absence of its cutting (sand blast) action upon the linings of the hot blast connections and of the iron and steel fittings where blast leaks are liable to occur.

The very large volumes of blast used in modern blast furnace practice naturally necessitate stoves of much greater heating surface than is required in the older practice. The modern hot blast stove is, therefore, constructed with a heating surface of 70,000 to 85,000 sq. ft.; checker openings are from 3 in. to 4 in. in diameter or square, enclosed in a shell 20 to 22 ft. in diameter and from 95 to 110 ft. in height. There are usually four stoves per furnace, though in some cases seven stoves are provided for two furnaces, one being arranged so that it may be used on either furnace. This is open to the objection that the two furnaces may at times both need the extra stove to the probable disadvantage of one. Each furnace should have its own complete equipment when both are in operation. The stove shells and their fittings and connections must be of considerably greater strength than in the older constructions to withstand the higher pressures they are subject to, and the latter of ample area to accommodate freely the large volume of air and gas passing through them.

A small but important feature in modern blast furnace equipment is the blast temperature regulating pipe, which consists of a connection between the cold and hot blast mains. The purpose of this connection is for admitting cold blast direct into the hot blast main to enable the regulation of the blast temperature, usually downward, when required. The cold blast connection may be made at any convenient point in the cold blast main, but the connection into the hot blast main should be at the farthest possible point from the furnace to intercept the blast from the nearest stove, in order that the cold and hot blast may have as great as possible time to thoroughly mix, as otherwise there is danger of the cold and hot blast entering the bustle pipe, or circular main, from which the tuyere connections are fed, not thoroughly mixed, when some of the tuyeres will receive blast of higher temperature than others with consequent uneven working of the furnace.

3. *The Raw Material Supply Plant.*—While unquestionably economy in the cost of handling the raw mate-

rials for supplying the furnace has grown to be a first consideration in the design of the plant under this heading, particularly in recent years of high labor costs, the original incentive to the adoption of mechanical handling was rather one of necessity. The rapid increase in blast furnace outputs necessitated such large quantities of materials that they could not be efficiently handled, if at all, by the older methods of manual labor. It was therefore necessary to install mechanical charging devices. Labor displacement rather than necessary labor saving was the primary incentive, though the latter was undoubtedly recognized as an important consideration.

A very important labor saving feature is that the raw materials shall be delivered to the works, when by rail, in self discharging hopper wagons of as large capacity as possible, with "one man" opening and shutting doors; when by sea direct from ship, by means of large capacity grabs to a transfer traveling bridge, which delivers the material so received direct to the furnace bins, to the stockyard situated adjacent to the bins, and directly under the transfer bridge, or into railway cars. The bins usually consist of a double row of slanting bottomed enclosures, constructed of steel or concrete, varying in number according to varieties of ores used, and running usually in a direction perpendicular to the length of the transfer bridge, the inclination of the bottom being towards the center line between the two rows of bins and at an angle somewhat greater than the angle of repose of the materials. The bins are each of moderate capacity, but in total capacity usually sufficient to supply the furnace for from 48 to 72 hours only, as by means of the transfer bridge ample facilities are at hand to keep them filled from the stock piles if necessary. Each row of bins forms the support for a standard gauge railway track for conveying to and discharging into the various bins such materials as are received in railway wagons. A transfer car also runs on this track, or on a separate track supported by the bins, for distributing the materials delivered by the transfer bridge from the stock piles or direct from the ships. The railway cars are elevated to the roads over the bins, either by an electric lift, or over an incline where there is sufficient room, the wagons descending to the ground level either over the same incline or a similar one at the other end or by means of a wagon drop.

Below and on the center line between the double row of bins there runs an electric transfer car for conveying the materials from the bins to the hoist skip or bucket. The materials are discharged from the bins by gravity into a receptacle on the transfer car, through suitably controlled openings situated at the lower limit of the inclined bottoms of the bins. The transfer car also carries as an integral part of it a weighing machine, upon the beams of which rests the receptacle for receiving the materials from the bins, so that any predetermined weight of material may be discharged into the transfer car receptacle from any particular bin. The whole of the operations in connection with the transfer car are carried out by the driver of the car, whose position is such that he has under his control and observation the discharge of the materials from the bins, the weighing of the materials, and the driving of the car. The capacity of the transfer car is such that it can deliver in each trip a quantity equal to the maximum load of the hoisting skip or bucket.

Various means are in use for assuring that the materials are well distributed as they discharge into the transfer car receptacle. From this receptacle the materials are discharged through a suitably controlled door in the bottom into the hoist receptacle, or, as in some arrangements, the transfer car receptacle is hoisted direct from its seat on the car to the top of the furnace.

Several methods of hoisting the materials to the top of the furnaces are in use in modern blast furnace equipment, which may be divided into two classes—the skip inclined hoist and the tub or bucket hoist, the latter consisting of either an inclined bucket hoist, or a vertical bucket hoist with a horizontal transfer bridge at the top. As usual where several methods are in use for doing the same thing, engineers and operators differ as to which provides the greatest number of desirable features for its purpose. As far as this paper is concerned, however, the purpose is the same in each method, and the author does not, therefore, propose to enter into a discussion of their relative merits.

That purpose is obviously to deliver the solid raw materials required in the production of pig iron to the top of the furnace, and to distribute them as uniformly as possible on and around the furnace charging bell. This is a feature of the greatest importance, as has been shown in the discussion of the question of distribution under the section on Preparation of Materials.

4. *The Output Disposal Plant.*—The principal output from a blast-furnace is, of course, pig or molten iron, the others being slag and gas.

With modern blast-furnace equipment the pig, or casting, bed has ceased to exist as an essential part of the furnace equipment, the whole of the output being run into ladle cars of varying capacity, from the simple open top type of 30 or more tons to the large enclosed type of 100 or more tons capacity, though in some cases even the use of hot metal ladle cars is eliminated, as will be described later in connection with the casting machine. When the molten metal is taken to the steelworks receiver or mixer there is an end of it as far as the blast-furnace is concerned, excepting when the quality is not satisfactory to the steelworks manager. When all or any portion of the output is required in the form of pigs, the molten metal is run into ladle cars for conveyance to a casting machine, which is usually located at some point away from the furnace, convenient to railway connections, or as in some more recent arrangements, the casting machine is located adjacent to the furnace, the molten metal being run direct into a receiver from which it is teemed into the casting machine feeding troughs, thus eliminating the necessity for hot metal ladle cars, except for such molten metal as is required for steel-making.

Though several types of pig-casting machines have been designed, the original or Uhling design, with various modifications and improvements for handling the molten and cold metal, is the type most usually installed at present. This machine consists of an endless chain of cast-iron moulds of about 100 lbs. capacity each, and of a shape to allow a free discharge of the cold metal. The moulds are key bolted to a flexible frame carried on small flanged wheels which run on an inclined way rising from the pouring end. The molten metal is poured from the ladles, which are tilted by a power device, into a shallow basin from which it runs through feeding troughs into the moulds as they rise slowly from their return journey and pass under the discharge end of the troughs. To prevent the molten metal burning or sticking to the moulds, they are coated with a solution of limewater, which is sprayed upon them as they return to the pouring end upside down, under the machine, the limewater being blown upward by air jets in the lime tank. Owing to the heat of the moulds they quickly dry in readiness for the molten metal before they reach the feeding troughs. At the upper end of the train of moulds as they turn over to begin their return journey, the metal, which by this time has solidified (the incline is designed of sufficient length for this purpose), freely falls from the moulds on to a shute from which it discharges either direct into steel-bodied cars where it is water-sprayed for cooling, or on to an inclined travelling endless plate conveyor which passes with its burden of hot pigs through a water-filled tank of a length sufficient to cool the pigs below the ignition point of wood. At the upper end of the conveyor as it turns for the return journey the cold pigs slide off into a shute and are discharged into railway wagons.

Machines are built single strand or multiple strand according to the capacity required, each strand consisting of a single chain of moulds having a capacity of roughly 500 tons per 24 hours.

While the structural parts of these machines were formerly built entirely of steel they are now constructed of ferro-concrete, owing to its more lasting qualities and lower cost. In addition to the necessary facilities which it provides for casting the large outputs of the modern blast-furnace, the pig-casting machine, the successful and satisfactory operation of which has been thoroughly demonstrated through many years of use, has very much simplified the handling of molten pig iron by eliminating the many objectionable features of the older method of casting in sand beds, and breaking by hand or by hydraulic or electrical pig-breaking machines, besides effecting considerable economy of labor and saving in waste.

The disadvantages of sand-bed casting and the advantages of the machine method of handling molten pig iron may be enumerated as follows:

Disadvantages of the sand-casting method:

(1) Difficult and high-priced labor required.

(2) Large quantities of clean sand required.

(3) Imperfect results, core jumps, plated beds, irregular breaking, and irregularity in sizes of pigs and sows.

(4) Heavy waste in runner scrap.

(5) Slower melting of sand-covered pigs, and cost of melting the sand on the pigs, in the steel furnace.

(6) Deleterious effects of sand-covered iron in basic steel furnaces.

Advantages of the pig-casting machine method:

(1) Immediate removal of molten metal from the immediate vicinity of the blast-furnace. (This, of course, does not apply where the metal is run direct into a receiver adjacent to the furnace, as above described; but the author believes this arrangement has not yet been widely adopted, and is of opinion that, notwithstanding the slightly extra cost of ladle cars, it is better to remove the molten metal to a safer distance, in view of the disturbances which sometimes occur in the immediate vicinity of blast-furnaces through breakouts, explosions, etc.)

(2) Practically no manual labor required.

(3) Sand-free iron.

(4) Uniform size of pigs of iron, and no heavy sow pieces.

(5) Facilities for disposal of the output always in readiness.

(6) Great reduction in runner scrap produced when casting.

(7) Saving labor charges.

(8) No core-jumps or plated beds (unsaleable iron requiring extra labor for breaking and handling).

(9) A difficult and very trying class of labor is dispensed with.

(10) Where week-end iron only is cast, the difficulty of finding special labor for these days only is eliminated.

A discussion of this heading would not be complete without reference to the slag and gas, both of which form part of the furnace output.

While there are no special methods of slag disposal which may properly be said to apply particularly to modern blast-furnace practice, it may not be amiss to refer to some of the methods in use at modern plants.

The most usual method is, of course, that which is now generally used at all, except the oldest, layouts (where the slag is still run into beds, allowed to cool, then broken by hand or drop ball, and shovelled into wagons), that is, by means of large capacity, self-discharging, mechanically operated slag ladle cars, in which the slag is conveyed to some point more or less distant to get it out of the way.

Where, however, recovery of the slag is desired for special commercial purposes, special methods are used, such as blowing steam through the molten slag for the production of slag wool; running the molten slag into tanks of water for granulating for cement making or other uses; running into special receptacles and cooled in layers for producing a solid product for concrete making, etc. As stated, these processes are for special purposes, and do not apply generally.

With regard to the gas there are a few points also which may be mentioned.

In view of the large volumes of gas produced in modern furnaces with large outputs, it is of great importance that ample areas shall be provided in the gas out-takes at the furnace top, not only to provide for the large volume of gas to be discharged through them, but also to reduce its velocity to a minimum, in order to lessen as much as possible the tendency for the smaller particles of solid materials to be mechanically carried out with the gas. For this purpose it is usual to provide four equally distant outlets of the largest size consistent with structural safety. These outlet connections are inclined as steeply as possible upward, and are carried well above the furnace top before the gas is admitted to the downward connections, in order that any larger materials, which may at times be projected from the furnace, may fall back into it and not enter the downtakes.

In some designs baffles are placed in the elbow of the uptakes in such a position that they will intercept these heavier pieces, thus avoiding the necessity for carrying the uptakes so high. A further reason for the multiple equidistant outlets is to prevent any tendency of the gases in the upper portion of the furnace to channel towards one side, as they tend to do in older furnaces with one outlet, thus reducing the active area in the upper reducing zone of the furnace.

Method of Operation.

In the foregoing pages the author has endeavored to define in some detail those factors which enter into, and make possible, modern blast-furnace practice. They are the elements out of the adoption of which that practice has developed. He has therefore designated them "The Bases of Modern Blast-Furnace Practice."

Certain operative features have necessarily been referred to in connection with the discussion of these factors; but so many of the details of operation, or management of a blast-furnace, are based on practical knowledge, acquired only by years of experience and common sense, that any detailed discussion of them is not possible in a paper of this nature.

It would not, however, be complete without some reference to an essential difference in the method of operation by which the improvements in results, made possible by the adoption of these factors, are obtained, and the method of operation still prevalent in many localities where modern practice has not been adopted. In modern practice the nearest possible approach to uniformity in all controllable factors is a first principle in order to obtain the nearest possible approach to uniformity of action within the furnace. Reference has already been made to the importance of this question of uniformity in various connections, including uniformity or regularity of blast volume, irrespective of furnace pressure or resistance. In the older practice just referred to as still prevalent in many localities, the volume of blast is varied with the furnace resistance, that is, the varying conditions within the furnace are permitted to cause lack of uniformity or irregularity in the volume of blast delivered to the furnace. This method being contrary to the principle of uniformity of all controllable factors is totally inapplicable to modern practice.

As the principle involved in the comparison of these two methods of operation were outlined in some detail in the author's evidence before the Iron and Steel Industries Committee, he will not state them here. Suffice it to say that blowing by constant volume irrespective of furnace resistance is the method of operation essentially employed in modern blast-furnace practice.

The actual volume of blast per minute, the number, size, and length of projection of the tuyeres inside the crucible walls, the weight of coke per round of charge, the rotation of coke, ore, and flux in the charge, the degree of bosh wall cooling, etc., are all operating conditions determinable, for any particular furnace and set of materials, within certain limits by experience only.

BOOK REVIEW

Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Pig Iron.

Ed. 2, 40 pages, 1922. Carnegie Steel Company, Bureau of Instruction, Pittsburgh.

In 1896 a committee of the Engineers' Society of Western Pennsylvania edited and published "Methods for the Analysis of Ores, Pig Iron and Steel in Use at the Laboratories of Iron and Steel Works in the Region about Pittsburgh, Pa." The chairman of the editorial committee was the late Dr. Francis C. Phillips, and the methods contributed bear the names of some of Pittsburgh's most eminent metallurgists; the first two contributions, for example, are by John S. Unger and Frederick Crabtree who 25 years ago were in charge of local steel-works laboratories. Some 20 pages are contributed by J. M. Camp, but these contributions do not adequately indicate Mr. Camp's connection with the enterprise. He was in a large measure responsible for the project of compiling and publishing the collected methods; he arranged for the editorial services of Dr. Phillips; and the influence of his own practice during a long experience in local laboratories is reflected in certain contributions from other sources.

The above publication was a praiseworthy attempt to record the general practice in laboratories in the greatest steel-making center of America. In many laboratories it has been superseded by the "Methods" of the chemists' committee of the United States Steel Corporation. This committee was formed in 1907 to standardize practice in the laboratories of the corporation, and J. M. Camp, formerly chief chemist of the Duquesne Works of the Carnegie Steel Company, was appointed chairman.

The "Methods" of the Chemists' Committee have appeared in eight pamphlets each dealing with one definite problem in steel-works analysis. One of the earlier of these, concerned with the sampling and analysis of pig iron, was published in 1912 as a pamphlet of 34 pages. Its value was immediately recognized and approximately 1,500 copies were distributed. But during the past decade numerous shortcuts and refinements have been made in steel-works analysis, and many of the methods set forth in the original pamphlet no longer represent the best modern practice. The new edition, just published, has been largely rewritten. In its preparation the Chemists' Committee canvassed the various laboratories of the corporation and gave due consideration to all improvements in methods appearing in the original edition. One noteworthy advance featured in the new edition is the distinct improvement in carbon combustion apparatus.

Directions are clear and concise, and accompanied by drawings where necessary, as in the case of the test-piece and mold for sampling molten pig iron. Though intended for trained chemists, there is a brief statement regarding the character and use of reagents.

The chairman of the Chemists' Committee, J. M. Camp, is in charge of the Bureau of Instruction of the Carnegie Steel Company, and his experience in the instruction of employees of this company, coupled with his lengthy technical experience is doubtless largely responsible for the value of the methods and the excellence of their presentation. It is interesting to note the personnel of the sub-committee with whose cooperation the present pamphlet is produced. The original sub-committee in 1912 consisted of W. B. N. Hawk, William Brady, and C. H. Rich. The first two of these men are retained on the present sub-committee. C. H. Rich (deceased) was in 1912 chief chemist of the Clairton works of the Carnegie Steel Company. He was succeeded in that position by I. A. Nicholas who was later succeeded by H. E. Cambell who constitutes the third member of the present sub-committee.

The pamphlet is obtainable from the Bureau of Instruction, Carnegie Steel Company, Carnegie Building, Pittsburgh.

E. H. McClelland,
Technology Librarian.

Carnegie Library,
Pittsburgh, Pa.

By-Product Coking with Particular Reference to New Combination Oven

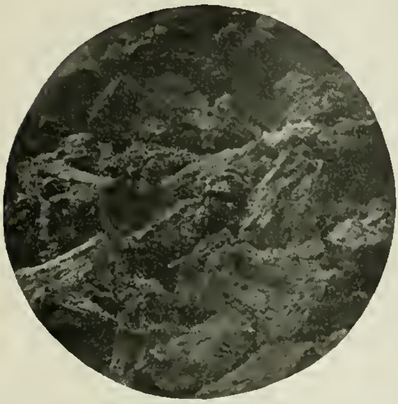

Fig. 1—Coke produced from 100 per cent Yorkshire coal coked at Seaboard By-Product Coke Company.

Comparison of American and European Methods of Coking, Giving Reasons for Superiority of Our Practice. Description of the New Koppers Oven.

By JOSEPH BECKER

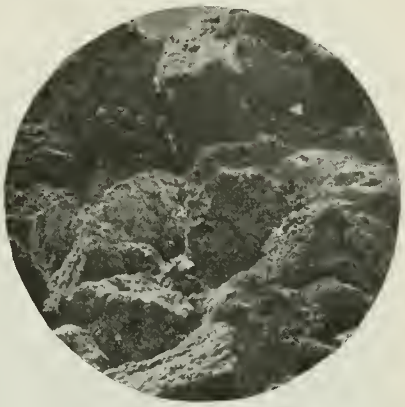

Fig. 2—Coke produced at Seaboard By-Product Coke Company from 100 per cent Durham coal.

BEFORE entering into the subject of this paper, perhaps it would be well to mention briefly the remarkable development which has taken place in the by-product coke industry in the United States in the past decade, particularly in its relation to the iron and steel industry with which it is so closely identified.

Not quite 15 years have elapsed since the United States Steel Corporation installed its first by-product coke plant of Koppers design, at Joliet, Ill., and since blast furnace operators were looking with doubt and suspicion on the by-product coke oven as a source of blast furnace fuel; but in this comparatively short time, the by-product coke oven has come to be an essential part of an economically operated iron and steel plant. It is not necessary for us to go into the causes leading up to this development—they are too well known to require even mentioning—but it is only fair to say that this result was only possible through the close co-operation which blast furnace operators have extended to those of us who had to do with the operation, construction and design of by-product coke ovens.

American By-Product Coke Oven Practice Superior.

It is no idle boast to say that America By-Product Coke Oven practice leads the world today—this despite the fact that the by-product coke oven originated and was in general use on the continent before it was even thought of in the United States. The writer had an opportunity last year to visit Europe and to study European by-product coke oven operation very carefully and what he saw convinced him that from the standpoints of quantity production per oven per day and quality of product, European practice is many years behind us. That very little, if any, progress has been made there in the past 10 or 15 years is brought out very clearly in an article in the September 2nd issue of "The Gas World" of London, describing an installation of 100 ovens for the purpose of carbonizing 540 tons of coal per day. This article goes on to say that the plant previously consisted of 100 horizontal flued waste heat ovens which have been in operation for 15 years. These ovens have a capacity of 7 tons and the 100 ovens carbonizing 500 tons of dry slack coal per 24 hours. This would be equivalent to 31 hours coking time. The additional 100 ovens recently completed are of the vertical flued type, and have a capacity of 7½ tons each with a carbonizing capacity of 540 tons of dry slack per day. This would be equivalent to a coking time of about 33 hours. This very strikingly shows that at least on this plant no progress has been made with respect to increasing the coking capacity per oven. It is remarkable that after 15 years a new plant is built which has even less carbonizing capacity per oven per day than the old plant, in spite of the enormous progress that has been made in the United States during the same period in the way of increasing oven capacity. This is merely citing one instance of English coking practice and the majority of English coke plants operate under very similar conditions. One wonders why conditions are not changed in England, in view of the large number of visitors who come to the United States every year to investigate our by-product coke plants.

The writer has observed similar things during his last year's visit in Germany. There have been recently put into operation ovens of the Koppers type, which are heated with blast furnace gas and which are supposed to operate on 18 hours coking time. These have an average width of about 16 inches and a length of about 32 feet between doors, making a carbonizing capacity of about 14½ tons per oven per day. This is very likely the largest capacity of any type oven of similar dimensions in Europe. However, even this capacity is low when compared with American coke oven capacities. Modern American ovens carbonize more than double the quantity of coal per day that can be coked in ovens as built in Germany and England. The Koppers Company has recently contracted to build a plant to carbonize 1,000 tons of coal per 24 hours in 37 ovens. The ovens are designed to carbonize

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*From a paper presented before the Eastern States Blast Furnace and Coke Oven Association at Buffalo, N. Y., October 5, entitled, "Modern By-Products Coking with Particular Reference to the Koppers Company New Combination Oven A." The author is Consulting Engineer, The Koppers Company, Pittsburgh, Pa.

30 net tons of coal per oven per day, and are of a type to be described later in this paper.

The question now arises—what is the reason for this great difference in coking speeds? Many have been advanced by our European contemporaries, the most prevalent of which is that they have to carbonize wet washed coals and that this makes it impossible for them to attain the same coking speeds possible here. This does not sound quite reasonable, and furthermore it is a fact that several plants in this country are using washed coals averaging 12 per cent moisture and more, and carbonizing them in from 15 to 17 hours in Koppers ovens averaging 17 inches in width.

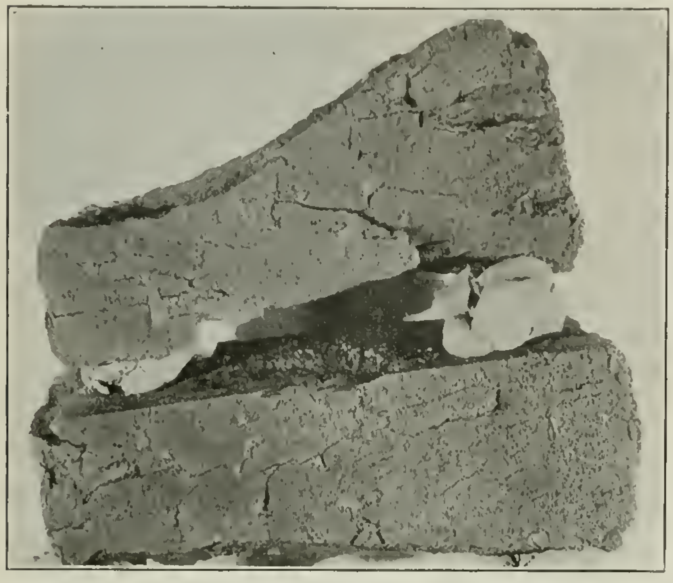

FIG. 3.
Coke section 100 per cent Durham coal coked at Seaboard By-Product Coke Company.

Another reason given is that the character of their coals is quite different from those found here. The writer has made an examination of the analysis and coking qualities of the various coals found there, and in general they correspond very closely to the coals found in this country—so this argument does not seem to hold.

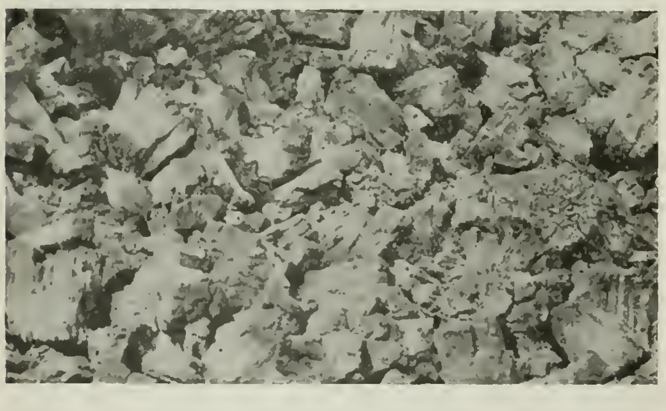

FIG. 4.
Coke from Yorkshire, England, coal coked in five-oven battery at Chicago in 11 hours.

Most striking proof of the fallacy of both these arguments was given during our recent coal strike, where several companies operating by-product coke plants imported large quantities of English coals to avoid curtailing operations. The Seaboard By-Product Coke Company at Jersey City, N. J., received over 100,000 tons of English coals such as Yorkshire and Durham coals, and coked them in 16 hours continuously with the same ease as American coals of different varieties used there, producing coke of very good quality for metallurgical purposes (see Figs. 1, 2 and 3). About 100 tons of Yorkshire and Durham coals were sent to the Chicago By-Product Coke Company's Coke Plant and separate coking tests were made in the new five-oven battery. These coals were perfectly coked at a coking time of 11 hours, without the slightest difficulty, and the coke produced was just as good for blast furnace use as any coke made in the Pittsburgh District from Pittsburgh coals (see Figs. 4 and 5). The capacity of this oven on these coals is, therefore, 25 net tons per oven per day.

Unquestionably one reason for their not being able to attain our coking speed is the fact that they do not generally use silica construction. On the other hand there are ovens of this material over there; but these have not attained anything approaching American practice.

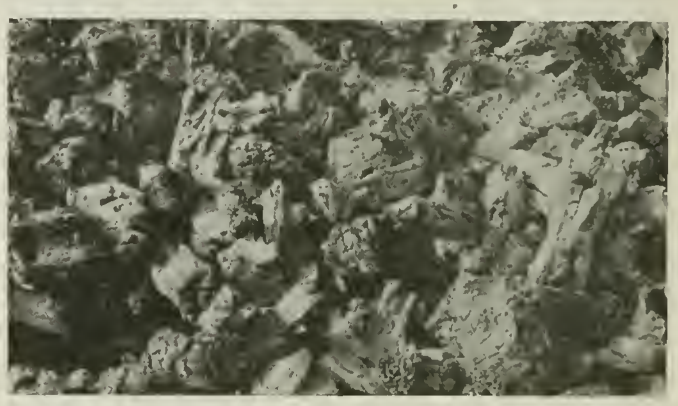

FIG. 5.
Coke from Durham coal coked in five-oven battery in 11 hours at Chicago.

Reasons for Superiority of American Practice Over Foreign.

In the writer's judgment, the difference in capacity of the American ovens as compared with those in Europe is due entirely to the proper use of properly manufactured silica material throughout, combined with better design, and last but not least, better operating organizations and more systematic operation.

The organizations operating the coke ovens in America consist generally of technically trained men with good practical experience, the latter not being generally the case in Europe. American operators have more tenacity in solving problems and difficulties in organization and operation in order to attain greater capacities from their plants and do not offer excuses for inability to maintain a high output as is done abroad. One of the most important features of organization to be found in American coke plants is the strikingly systematic operation of the ovens. Ovens are heated by intelligent heaters and most of the assistants and superintendents of American plants have passed through the entire school of by-product coke oven operation, beginning as heaters. Even in cases where this is not so, the assistants and superintendents fully realize the importance of oven heating and consider the oven operation the "heart" of the entire by-product coke plant. In European operation, on the other hand, insufficient talent and talent of a lower quality are employed to take care of the ovens. The result is that coke oven batteries need frequent repairs and relining, often after only three to five years of operation. In making this statement, I do not refer to plants using highly expanding coals or coals containing excessive amounts of sodium chloride which are coked in clay ovens instead of in silica ovens. The usual class of heaters employed in Europe are men who are not acquainted with combustion problems and who operate the ovens by rule of thumb methods. In most plants, it will be found that there is no pushing schedule at all. Ovens are picked out and pushed as they become ready so that it can be stated as a general rule, the ovens on the Continent operate the heaters, while in America the heaters operate the ovens. Taking all these things together, the result is that America can make the same quantity of coke from the same coals in less than one-half the number of ovens.

Another excuse usually offered is that with our fast operation we destroy by-products. The writer had an opportunity to investigate this and finds that the by-product yields here are fully equal to those obtained in Europe.

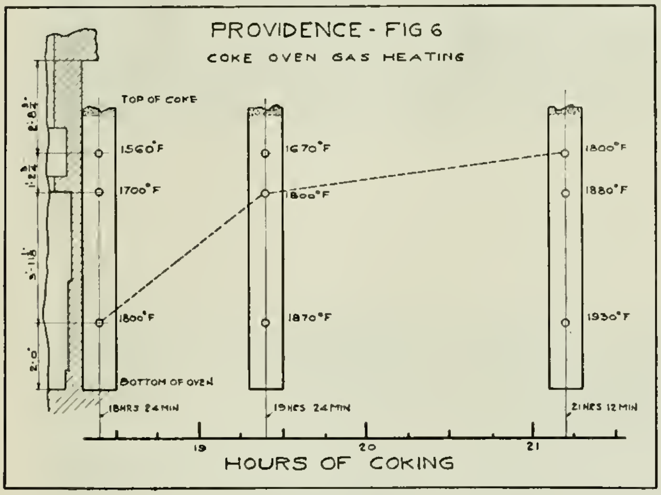

FIG. 6.
A heat progression chart for the old type Koppers oven.

The same inefficient operation described above can be found in European blast furnace practice and the poor operation of their by-product coke plants is a great contributing factor thereto. In America there is the closest co-operation between blast furnace and coke oven operators.

As is usual in American industrial practices the natural tendency in the building of coke ovens has been to attain a maximum capacity per unit oven while simultaneously producing a good quality of coke. Therefore the development in America has been a gradual increase in the size of the ovens. The use of high grade silica throughout the structure has reduced the time required for coking very considerably as compared with the use of clay bricks. But beyond the increase of capacity an improvement of the design of the ovens proper was necessary that long and high ovens could be built with proper heat distribution over the considerably increased coking areas.

The problem of designing ovens which would assure a perfect distribution of heat over such large areas was a difficult one. A great number of coke plants were desirous of coking 100 per cent high volatile coals. The blast furnace practice showed that coke made from such coals should be pushed at relatively lower temperatures. When pushing coke made at low temperatures, any uneven heating conditions in the ovens becomes much more pronounced and visible than when pushing hot coke. Furthermore, it is a matter of course that the heating system of ovens of large capacities has to allow passage of larger volumes of gas such as waste products of combustion through their flues. This calls for proportionately larger areas to convey such gases, in order to prevent great pressure drops throughout the heating system, which would seriously interfere with the proper operation of the ovens.

The Koppers ovens with individual regeneration and flame heating in the flues produce very good coke in ovens of the capacity commonly in use today. The heating from the bottom up to the horizontal flue is practically uniform, however, the region of the horizontal flue lags behind in coking. Fig. 6 shows a typical progression of temperature into the coal charge at various places in such an oven. These readings were taken by inserting thermo-couples through the Pusher side door four feet into the coal charge; one was located two feet above the oven floor, one just below the horizontal flue and another one at about the center line of the horizontal flue. The figures given herein are an average of a great number of readings and exhibit in general the conditions as they exist in practically all the Koppers coke ovens which are heated reasonably well and operated to capacity. This indicates that the space occupied by the horizontal flue is quite appreciable and the amount of coke in the upper region of the ovens being affected by the location of the horizontal flue is an appreciable percentage of the total coke made. This condition is tolerable, particularly when the ovens are pushed without waiting until the upper part is thoroughly coked, and such coking operations with these ovens have given very good blast furnace results. These ovens have an average capacity of about 18 to 19 net tons of coal per 24 hours.

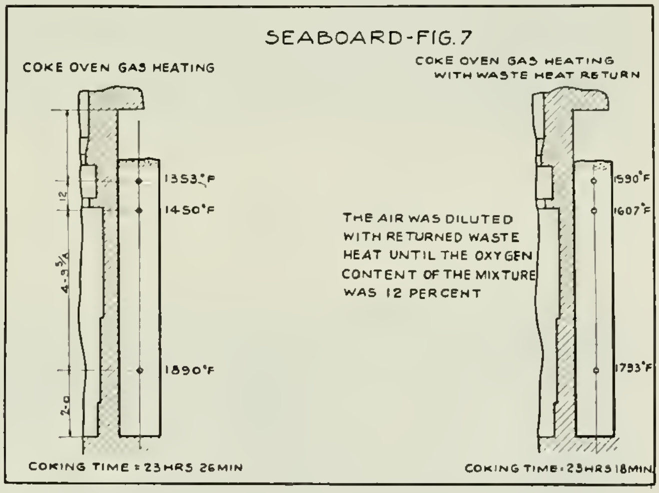

FIG. 7.
Heat progression chart for coke oven with waste heat return.

It will be interesting to know the results of an investigation of the heat progression in the coking charge in an oven that was designed for 17 hours' operation but operated between 23 and 24 hours. Such tests were made at the Seaboard By-Product Coke Company's plant by inserting thermo-couples in the coal charge in the same way as in the tests described before. The test disclosed that on that coking time the lower part of the oven coked decidedly faster than the part below the horizontal flue. When the lower part of the coke reached the temperature of 1,890 deg. F., the part below the horizontal flue only had a temperature of 1,450 deg. F. These temperature differences could, of course, be expected, because when operating on a longer coking time the quantity of gas per flue becomes correspondingly less and combustion is relatively quicker, thus causing a quicker progression of the coking in the lower part as compared with the upper part of the oven.

Uniform Heat Distribution Important.

As far back as 1914, Dr. Koppers proposed as a means of evening out temperatures within the heating system of coke ovens, the addition of waste gases to the air required in order to retard the combustion of gases in the heating flues because of the reduced content of oxygen in the waste gases and air mixture and thus lengthening the flame, resulting in an improved heat distribution and temperature progression within the coal charge. This process was tried out at Seaboard and Fig. 7 shows the result of the addition of waste gas till the mixture of waste gas and air contained 12 per cent oxygen. The waste gas was taken from the stack by means of a fan and blown into the air boxes on the regenerators, while the air was drawn in according to the regular practice. The temperature mentioned before when operating on between 23 and 24 hours were decidedly changed and shows that the bottom temperature was reduced to 1,793 deg. F. while the temperature below the horizontal flue was increased to 1,607 deg. F., simultaneously increasing the temperature in the coke near the region of the horizontal flue to 1,590 deg. F. This test was carried on for several weeks and it was shown that when the fan was taken off the temperature went back to the original ones as mentioned before. This test proves that the return of waste gases in ovens which have unequal heating conditions from bottom to top will greatly help the distribution of heat progression in the coking charge. It is a good cure for ovens which suffer from hot bottoms as it causes a condition in the heating flues which is similar to that existing when using blast furnace or producer gas. Blast furnace and producer gas are most excellent fuels for heating the ovens because such gases have a slower combustion speed and distribute the heats very uniformly.

Principles of Design.

It is the belief of the majority of coke oven and blast furnace operators that, especially from high volatile coals, better coke can be made in narrower ovens. In making the oven narrower, the coking capacity per 24 hrs. would necessarily be reduced unless a considerable multiplication of the operations would be resorted to. The first thought would naturally be to compensate for this by building higher and longer ovens and thus increasing the tonnage per oven per 24 hours. This would mean that the horizontal flue, with the type of oven as mentioned before, would have to be enlarged and thus occupy a larger space in the coking region, thereby retarding the coking of a proportionately larger amount of coal in that region. Furthermore, when

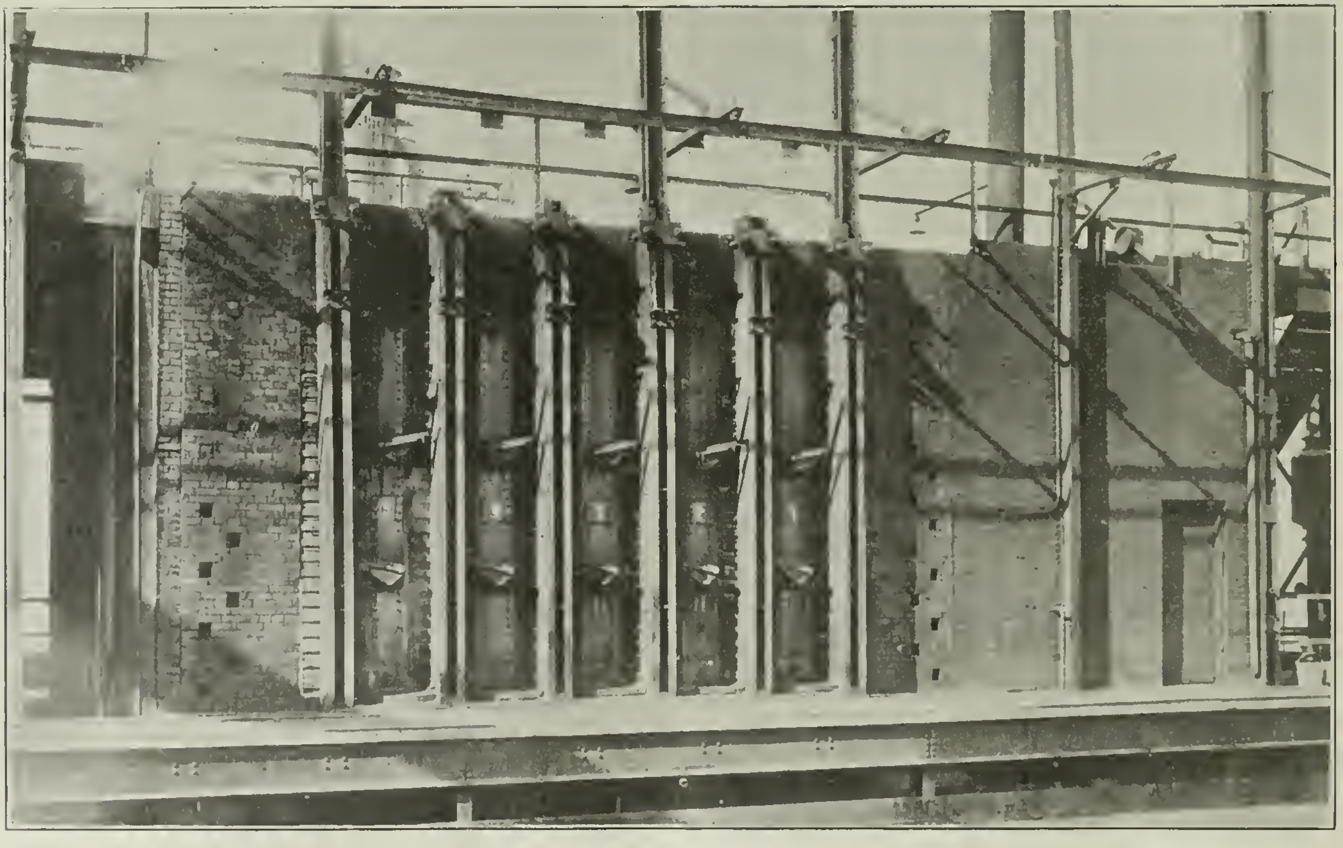

FIG. 8.
Coke side of new combination type Koppers ovens at the plant of the Chicago By-Product Coke Company, Chicago.

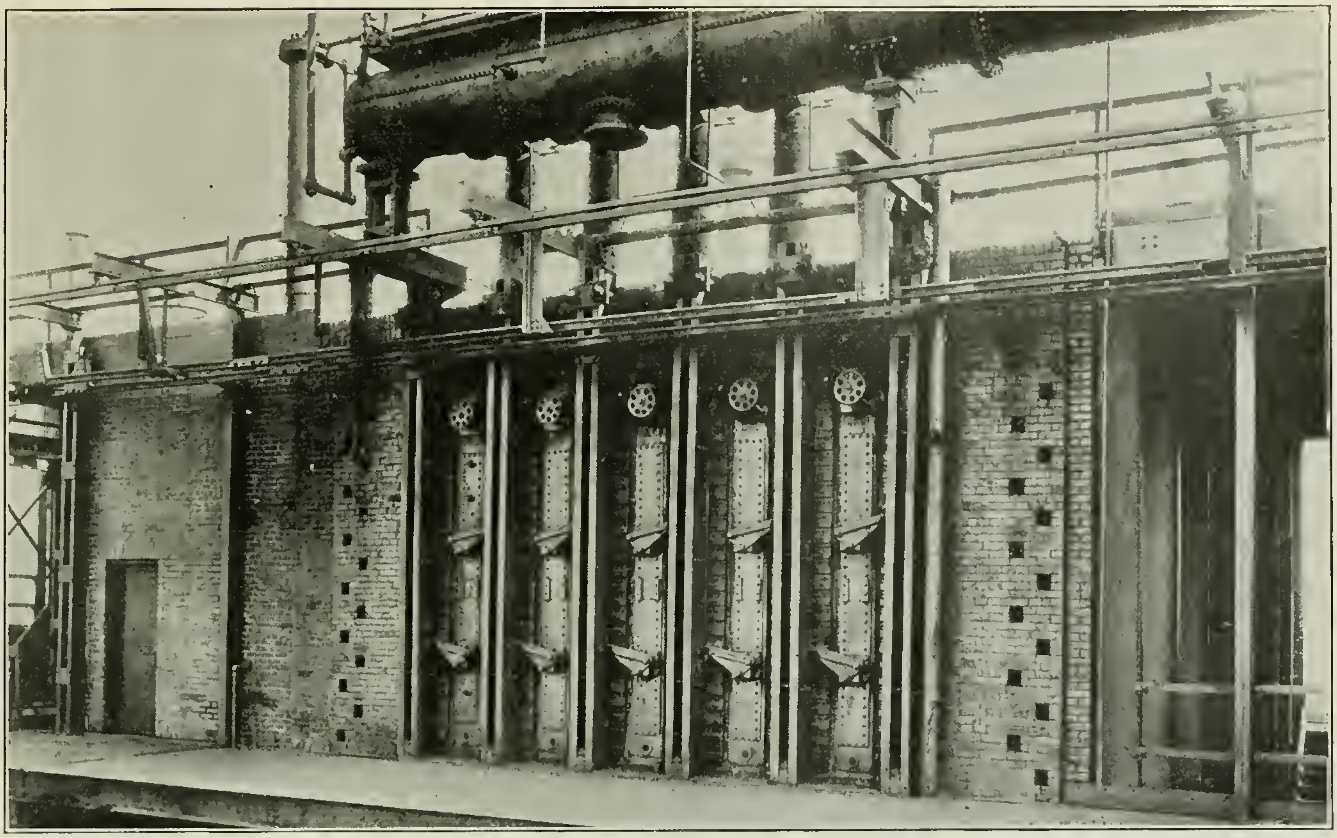

FIG. 9.
Pusher side of new Koppers oven at the Chicago By-Products Coke Company, Chicago.

equipping ovens so that they can be heated in the future with producer or blast furnace gas which is unquestionably the proper construction, this flue must be enlarged again in order to make it carry the additional amount of inerts present in such low Btu. gases. It, therefore, was apparent that the oven as it stood should not be increased in capacity without making changes in the design eliminating the effect of the horizontal flue on the heating conditions and thus eliminating its effect on the quality of coke produced. Also with increased capacities a relatively smaller horizontal flue would require an exaggerated closing of the discharge openings of the vertical flues to such an extent that the drop of pressure through the reduced openings would become too high for the best draft conditions throughout the oven structure. It is, of course, fully recognized that an oven can only be successful in operation, production and length of life provided the draft in the heating flue system be kept at the very minimum.

It might be thought best by some to design ovens without any horizontal flues. Such ovens without horizontal flues usually operate in such a manner that adjacent vertical flues serve alternately as up-burning flame flues and down-going waste gas flues and vice versa. It is evident, however, that an oven in which all adjacent heating flues or at least a large group of them serve at the same time in their entirety as up-burning flame flues or in their entirety as down-going waste heat flues, is not subject to the danger of different draft conditions between adjoining flues. In this case, the up-burning flame flues can under no condition be affected by adjoining down-flow flues in case there should be any leakage in the brickwork separating such flues, a condition which can easily occur especially as the ovens become older. Furthermore, the arrangement of the gas supply flues in an oven in which the gas is burned up in one flue and down the next adjoining one is usually such that this gas supply flue is paralleled by an up-going regenerator on the one side and a down-going regenerator on the other side. This arrangement greatly increases the difficulty of keeping the gas supply flues tight. Also all ovens should be built so that producer gas or blast furnace gas could be used advantageously in the future, and in up and down-flow flued ovens, there will always be a counter current between waste gas and gas in regenerators, as well as between adjacent flues. All these dangers of leakage between adjoining flues are non-existing in ovens with paralleled flow and it is, therefore, clear that it is best to retain a horizontal flue because it insures simplicity in design and the greatest safety in operation of the ovens. Furthermore, it makes the system readily adaptable for the use of blast furnace and producer gas, without the objectionable counter currents.

Experimental Ovens Tested In Chicago.

These leading principles in oven construction have been tried out by the Koppers Company in a battery of 5 ovens at the plant of the Chicago By-Product Coke Company at Chicago. The five ovens were put into operation on February 1, 1922, and have since that time operated continuously on a great variety of coals at coking times between 10 and 12 hours. Fig. 8 shows the coke side of this battery; Fig. 9 shows the pusher side, and Fig. 10 shows the location of this battery in connection with the rest of the ovens. The new oven has a length of 37 feet between doors, a height of chamber of 11 ft. 8 in. and an average width of 14 ins., the taper between coke side and pusher side being 1½ ins.

Cast iron jambs are used at the ends of the ovens. Fig. 11 shows the general design of the new type oven. The vertical cut through the oven lengthwise the battery shows the heating walls, coking chambers, arrangement of regenerators and the crossover flue communicating with the heating walls on both sides of the oven chamber.

This shows that in this new design one side of the coke oven is heated in its entirety, that is, gas burns simultaneously on the coke side and on the pusher side, the products of combustion then join in the respective horizontal flues, pass through the crossover flues, one of which is located on the coke side and the other on the pusher side. Thence the products of combustion enter the respective horizontal flues of the adjacent heating wall and pass downwards throughout the entire wall into the respective regenerators. It is evident that the cross sectional area of a horizontal flue when operating in such a way can be considerably reduced as compared with the horizontal flue in ovens of the former design. This allows us to locate the horizontal flue higher than was previously possible and it furthermore allows the use of heavy walls between the horizontal flue and the coal chamber. This gives sufficient space to use insulating material if necessary in order to prevent any overheating of the gas space in the oven chamber. The insulation of the crossover flues at Chicago has been found to be entirely satisfactory and effective.

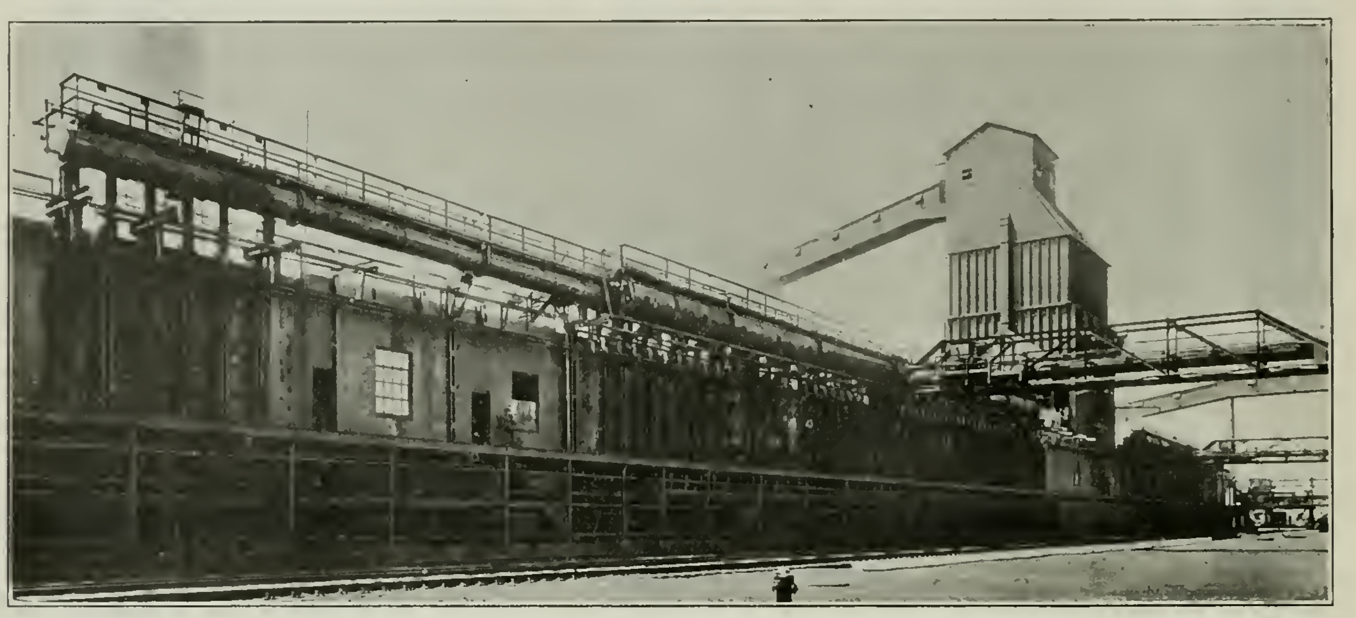

FIG. 10.
Pusher side of ovens at Chicago By-Product Coke Company with new type combination oven in the foreground

Increased Height of Flame Flue Heating.

One of the most important achievements claimed for this new design is the fact that the height of the flame flues has been considerably increased and these now extend as far up towards the top of the coal charge as is necessary for uniform heating of the entire charge. Thus the interference of the horizontal flue with the flame flue heating has been entirely eliminated. Of course the number of crossover flues could be increased beyond two perferably to five, the crossovers passing through the available spaces between charging holes. The size of the horizontal flue would thus of course be still more reduced, without causing an additional pressure drop. For ovens of 12 ft. in height and of a length similar to the Chicago oven, it has been demonstrated at Chicago that only two crossovers are required to permit a size of horizontal flue that does not interfere with flame flue combustion and a flue which is consistent with good strong wall construction. However, there is very little reason why ovens should not be increased further in height and length, and it might then be preferable in order not to increase the size of the horizontal flue to build three or five crossovers. It is clearly shown that with this new design the size of an oven has become independent of areas required for the former horizontal flue which interfered with the perfect operation of the ovens, especially when they were of great capacity, since it is important to retain the advantageous functions of horizontal flues.

It should be emphasized that on account of the fact that an entire side of a coke oven chamber serves either for up-flow combustion or down-flow products of combustion, any leakage between individual flues become of little consequence because all the gases flow either up or down and each flue is operating under the same pressure conditions. Since there is absolutely no counter flow in any of the heating flues, it undoubtedly constitutes the safest construction for flame heated coke ovens. It will also be noticed that the regenerators reverse longitudinally with the battery instead of crosswise as in the former design. The usual longitudinal taper of a coke oven requires that larger amounts of fuel gas are used on the coke side as compared with the pusher side. In the type of oven formerly built, products of combustion from the coke side of the oven chamber exchange their heat with the air or air and gas going up to the narrow pusher side. Since for the latter side gases are required in smaller volume, the efficiency of the heat exchange varies with reversals as is shown by fluctuations in the stack flue temperature. In this new construction the in-going gases for each half of the oven are regenerated with the products of combustion from that half, and it is thus possible to maintain a lower uniform stack temperature which is the nearest practicable approach to the theoretical.

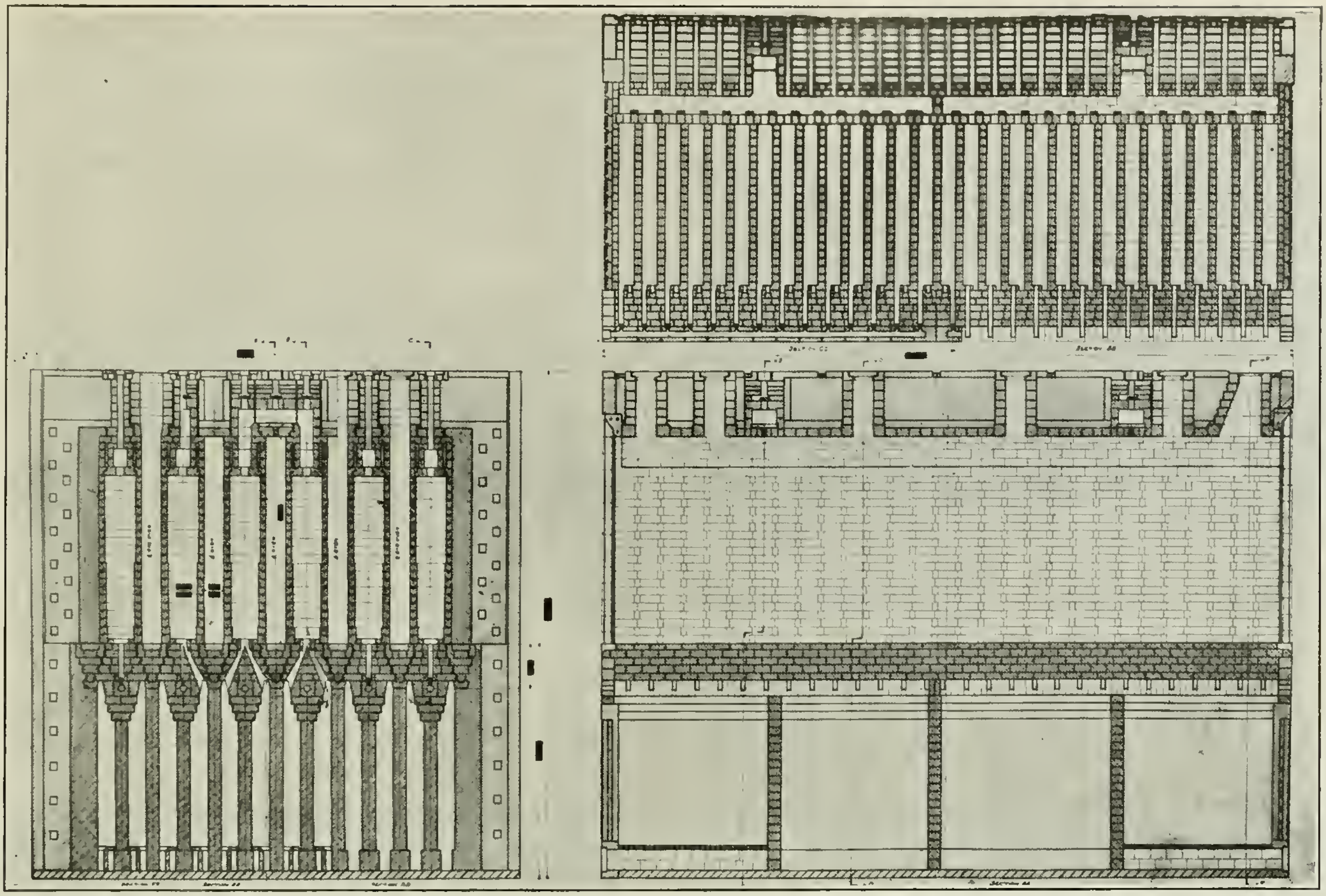

FIG. 11.
Plan and cross section of the new combination oven of the Koppers Company.

Minimum Leakage—No Counterflow.

It will also be noticed when air flows upward in two regenerators that the gas supply flue located in the supporting wall separating these two regenerators is operating also for up-flow combustion while the adjoining heating wall operates for discharge of waste gases and consequently the gas supply flue located in that particular regenerator wall is not in operation. In other words there are hardly any pressure difference between up-flowing regenerators and gas supply flues and consequently the leakage of the gas distributing flue will be reduced to a minimum.

Figs. 12, 13, 14 and 15 show the flow of gases when using coke oven gas and blast furnace or producer gas. Figs. 14 and 15 show the oven when operating on producer or blast furnace gas. When producer gas or blast furnace gas of low heating value is used for heating the ovens, it must be preheated in order to obtain the desired temperature and to operate economically. This preheating is accomplished by passing the gas through separate regenerating chambers on its way to the heating walls. In the new design of oven the arrangement of regenerators and flow of gases is such that there does not exist at any time a counter flow between incoming fuel and out-going products of combustion in adjacent regenerator chambers. Fuel gas and out-going products of combustion are always separated by a regenerator containing in-going air. Should there be a slight leakage into the waste gas regenerator chambers, it would only result in loss of air, while it would be impossible to lose producer or blast furnace gas.

The battery of 5 ovens of this new design at Chicago was operated on 11 hrs. coking time for several months with producer gas having a heating value purposely varied between from 85 to 125 Btu. and it was demonstrated that the oven when heated with this producer gas gave most satisfactory results as to heat distribution and fuel consumption. It was absolutely evident that there was no leakage of producer gas into waste gas on account of producer gas and air flowing in parallel and a counter-flow only existing between air and waste gas.

It has been demonstrated that on the 5 ovens at Chicago the arrangement of regulable ports in that construction is correct for both conditions, that is, when using straight coke oven gas or producer gas. See Fig. 16. The same small temperature difference between top and bottom when using coke oven gas was observed as when using producer gas.

The tests for determining the progression of coking at different elevations in the oven chamber as made at the Providence Plant were repeated with the same instruments and in the same manner on these 5 ovens at Chicago and the results obtained were most gratifying. See Fig. 17. The absence of the interference of the horizontal flue together with the unique design of adjustable air ports gave a distribution of heat in such a way that the entire mass from top to bottom and from end to end was finished at the same time, the difference in temperature usually not exceeding 100 deg. F.

Coke of Uniform Quality and Size.

The coke produced from these new type ovens was

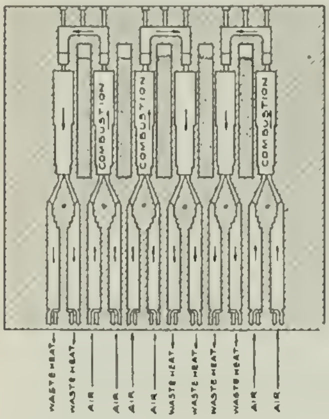

FIG. 12
Coke oven gas heating.

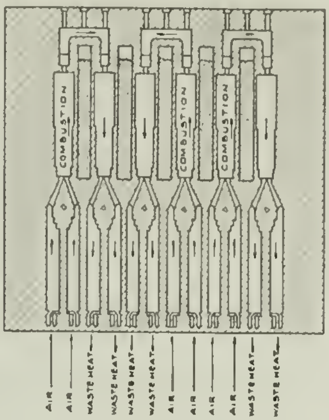

FIG. 13.
Coken oven gas heating—reversal.

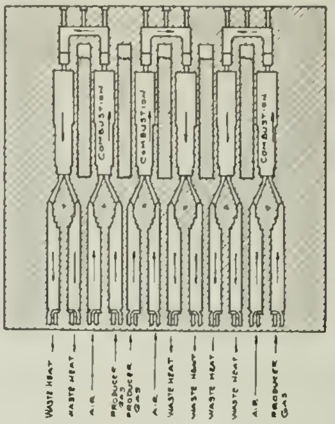

FIG. 14
Producer gas heating.

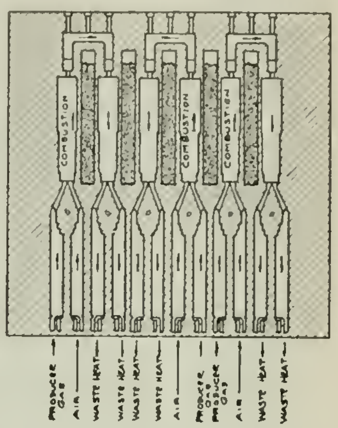

FIG. 15.
Producer gas heating—reversal.

decidedly more uniform than that produced from the older ovens. The large pieces of coke originating near the horizontal flue region of the older oven were entirely absent in the coke from the new oven and the coke from the bottom part of the new oven was just as large as the coke from any other part of the oven.

Shatter tests and combustion tests have been made from coke out of different elevations of the new ovens and it has been found that the combustibility of the coke from the lower part of the ovens is the same as that taken from the upper part of the ovens. It was further shown that the shatter tests from the upper part of the oven are virtually the same as the shatter tests from the coke produced in the lower part of the oven. This indicates that besides very uniform size of coke produced in this new oven, the characteristics of the coke from different parts of the ovens show great uniformity.

In making coke of 11 hours in this new design of oven, the temperature of the flue walls did not exceed the maximum of 2,550 deg. F. and the fuel consumption in coking Pittsburgh coals was equivalent to 1,050 Btu. per pound of coal.

The advantages claimed for this new oven are as follows:

1. Greatest simplicity of design.
2. Perfect distribution of heat in such a way that the coking within the coal charge progresses uniformly at all places, thus preventing any over and under coking.
3. Increased capacity per oven unit.
4. Lowest fuel gas consumption.
5. Maximum strength of oven walls.
6. Lowest pressure differentials throughout the entire oven system.
7. Complete absence of counter-flow between flame flues and gas supply flues and gas regenerators.

All of the above mentioned improvements will guarantee the long life of the oven structure and the continuous supply of most uniform coke at the lowest fuel consumption and operating expense. It should be emphasized that the low draft conditions existing in these ovens is of great importance because it insures long life of the oven. It is a well known fact that high draft conditions in ovens always results in early oven repairs and loss of products.

The foregoing shows that the coking of coal can be done in the most uniform manner and the only matter to be decided upon in individual cases would be the width of oven that would be proper for certain coals to produce the best blast furnace coke in respect to size of coke and its properties as to combustibility. Furthermore, at what temperatures or in length of time should coals be coked to produce the coke that gives the best blast furnace results. From all observations made so far it seems to be correct for straight high volatile coals to build the ovens as narrow as is practical because this produces a coke of less fingery structure and cross fracture than when made in wider ovens.

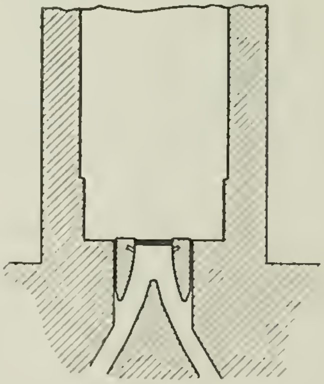

FIG. 16.
Showing the adjustable air port of the new Koppers oven.

There is usually a variation in the coke starting with the wall side and ending at the center of the oven. This variation is greater in wider ovens than in the case of coke made in narrow ovens. In making tests of a piece of coke and taking samples from the inner end of the coke, the middle and the outer end of the coke, it has been observed that the specific gravity and porosity of the coke changes from center to end, and that in wider ovens the cauliflower and dense end penetrates to a greater depth than in narrower ovens. It has been observed in the coke made in the 5-oven battery at Chicago that a much more uniform porosity was practically maintained from one end to the other of a piece of coke. Coals coked in narrow ovens give a higher yield of tar than when coked in wide ovens, indicating that the smaller yield of tar must have been accompanied by formation of additional gas and residue of carbon which is deposited on the cell walls of the coke. However, carbon coke made from tars is very refractory and combustion tests on carbon coke made from tar subjected to a temperature corresponding to that of coking operation—that is about 1,800 deg. F. showed that the combustibility of such material was decidedly less than the combustibility of ordinary coke. This would again indicate that a given coal when coked under conditions which yield the maximum in tar would produce a coke of greater combustibility than when coked under conditions where the tar yield is relatively low. For these reasons it is advisable to build as narrow ovens in so far as is practicable and consistent with economical operation. Since the time for coking is shorter in narrower ovens, particularly in this new type of oven, the coke is exposed for less time to the detrimental effect of high temperatures which again insures maximum combustibility of the coke, a quality which lately has been emphasized as being most important by men prominent in the coke oven and blast furnace industry.

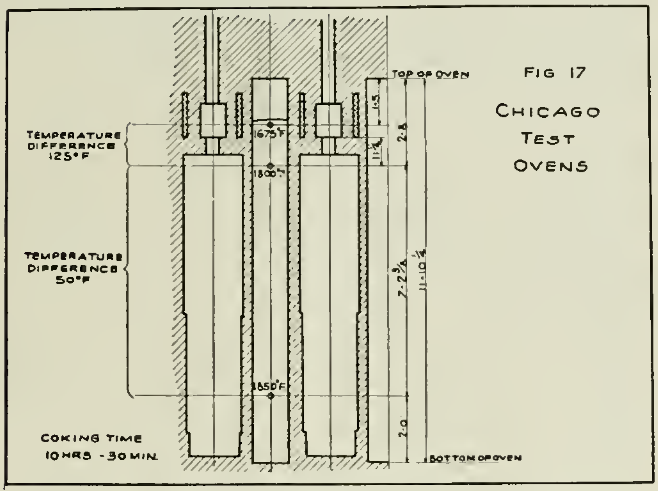

FIG. 17.
A heat progression chart for the new combination oven.

FIG. 18.*
Coke from Black Briar Illinois coal on the coke wharf at the Chicago By-Product Coke Company.

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*The subject of making a good grade of blast furnace coke from Illinois coals has been a much mooted one. Large scale oven tests made by the Koppers Company in 1911 showed that Illinois coals would make a good grade of blast furnace coke and subsequent tests made by the Bureau of Standards in 1917 conclusively demonstrated that such was the case. (See Bulletin Bureau of Standards No. 37, entitled, "Coking of Illinois Coals in Koppers Type Oven.") Fig. 18 shows coke from 100 per cent Black Briar Illinois coal, made in the experimental battery of five ovens described in this paper. A large quantity of this coal was coked at the time and the results further demonstrated that not only would these coals coke, but that they made a very excellent grade of blast furnace coke on as short a coking time as 11 hours. Three hundred and sixty-eight ovens of this type are under construction for the Carnegie Steel Company at Clairton and 37 ovens of this type are now under construction for the Weirton Iron & Steel Company at Weirton, W. Va.

Discussion of Heat Balance

A Table Prepared from Prof. Trinks' Article on "Heat Balances in Steel Plants" for Purposes of Comparison and Study.

By J. B. CRANE*

PLANT No. 1. Heat balance of an uneconomical steel plant based on one pound of finished steel. This heat balance is used on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap iron per lb. of finished product. 2,200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 7,000,000 Btu. required in open hearth per long ton of ingots produced; 1,100,000 Btu. in soaking pits per ton of ingots; 4,500,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, non-condensing. All auxiliaries steam operated. Steam blowing engines, non-condensing. Beehive coke ovens. (Note: All figures represent Btu. per lb. of finished steel.)

Plant No. 2.

Heat balance of an average steel plant. Based on one pound of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent cold pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished steel; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 2,200 lbs. of coke used in blast furnaces per long ton of pig iron produced. 6,000,000 Btu. required in open hearth per long ton of ingots produced; 1,000,000 Btu. in soaking pits per ton of ingots; 3,800,000 Btu. in reheating furnaces per ton of blooms or billets. Mills driven by steam engines, 150 lbs. saturated steam, 20-in. vacuum. Blast furnace auxiliaries steam operated, all other auxiliaries electrically operated. Electric power supplied by turbo-generator, steam blowing engines and turbo-blowers, 150 lbs. saturated steam,

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*George T. Ladd Company, Pittsburgh.

20-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.

Plant No. 3.

Heat balance of an uneconomical steam operated steel plant. Based on one pound of finished steel. This heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product is rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 1,800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu. required in open hearth per long ton of ingots produced. 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas, blast furnace gas and producer gas is used in reheating furnaces and in pits. Mills driven by economical steam engines, operating with steam at 200 lbs. pressure, 100 deg. superheat, 27-in. vacuum. Blowing engines steam driven, same conditions as above. Blast furnace auxiliaries steam operated, other auxiliaries electrically operated. Electric power supplied by turbogenerators, 200 lbs. steam pressure, 10 deg. superheat, 28-in. vacuum. (Note: All figures represent Btu. per lb. of finished steel.)

	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4
Btu. to coking coal	13,260	11,466	9,360	9,360
Btu. to boilers	6,480	2,835	3,358	
Btu. to producers	9,450	5,230	1,132	2,202
Total Btu. for 1 lb. of steel....	29,190	19,531	13,850	11,562
Btu. lost in coking coal..........	6,025	1,780	1,515	1,517
Btu. waste in coking coal........		350	298	298
Btu. in tar to open hearth........		610	500	500
Btu. to furnaces (CO gas)......		1,324	1,085	1,085
Btu. to boilers (surplus CO gas)		189	157	155
Btu. used in smelting slag radiation	2,605	2,583	2,270	2,270
Btu. B. F. gas—waste	465	463	353	353
Btu. B. F. gas—stoves	1,480	1,482	1,132	1,132
Btu. B. F. gas—blowing				442
Btu. B. F. gas—boilers	2,685	2,685	177	177
Btu. B. F. gas—melting			1,873	1,067
Btu. B. F. gas—gas engines				364
Total Btu. in coking...........	13,260	11,466	9,360	9,360
Btu. lost in boiler	3,210	1,859	956	
Btu. lost in condensers	2,087	979	791	
Btu. to blowing engines	1,511	1,075	640	
Btu. B. F. auxiliaries	640	640	646	
Btu. blooming mills	460	370	405	
Btu. bar and shape mill..........	714	503	301	
Btu. turbine and miscellaneons...	543	283	214	
Total Btu. for power..........	9,165	5,709	3,953	957
Btu. obtained from B. F. gas....	2,685	2,685	177	541
Btu. obtained from coal	6,480	2,835	3,358	
Btu. obtained from CO gas		189	157	155
Btu. obtained from waste heat O. H.			261	261
	9,165	5,709	3,953	957
Btu. lost in producers	2,366	1,308	284	548
Btu. to open hearth	3,935	3,375	2,700	2,700
Btu. to soaking pits	619	563	506	506
Btu. to reheating furnaces	2,530	1,918	1,100	1,100
Btu. recovered from O. H.......			261	261
Total Btu. for furnaces........	9,450	7,164	4.590	4,854
Btu obtained from coal	9,450	5,230	1.132	2,202
Btu. obtained from CO gas		1,324	1,085	1,085
Btu. obtained from CO tar		610	500	500
Btu. obtained from B. F. gas....			1,873	1,067
	9,450	7,164	4,590	4,854

Plant No. 4.

Heat balance of an economical steam plant. Based on one pound of finished steel. The heat balance is based on 50 per cent scrap, 50 per cent hot pig iron being used in open hearth furnaces. One-half of the product rolled to 1-in. squares, one-half to 8-in. beams. 1.13 lbs. of blooms required per lb. of finished product; 1.26 lbs. of ingots; 0.675 lbs. of pig iron plus 0.675 lbs. of scrap per lb. of finished product. 1,800 lbs. of coke used in blast furnaces per long ton of pig iron produced. 4,800,000 Btu .required in open hearth per long ton of ingots produced; 900,000 Btu. for soaking pits per ton of ingots; 2,750,000 Btu. for reheating furnaces per long ton of blooms or billets. A mixture of coke oven gas and blast furnace gas is used for reheating furnaces and in pits. Power consumption includes blast furnace auxiliaries, rolling, cranes, lighting, shears, tables, etc. (Note: All figures represent Btu. per lb. of finished steel.)

STEEL PRODUCTION IN SOUTH AFRICA GROWING

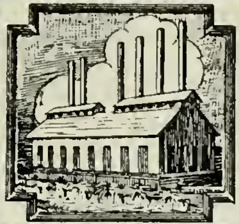
Steel production in South Africa is making considerable progress, according to a report to the Department of Commerce from Trade Commissioner Stevenson, though not as much as had been anticipated.

The Union Steel Corporation (of South Africa) Limited, Mr. Stevenson says, is by far the most important factor in the industry, its 1921 production being 14,434 tons of a value of £361,468. The greater part of the output, or 11,573 tons, consisted of open-hearth steel made from scrap materials, while 2,861 tons were made in a 3½-ton Heroult electric furnace. A new 22-inch mill is being installed to roll heavier sections of angles, channels, girders, and similar products from 20 to 30 pounds per foot, and rails up to 60 pounds per yard. A new 25-ton Siemens open-hearth furnace has been erected and when in full working order the capacity of the works will be 30,000 tons a year. The Union Steel Corporation has already supplied a large part of the reinforcing steel contract for the government grain elevators, and has rolled a few rails which have been purchased by the South African Railways for trial purposes.

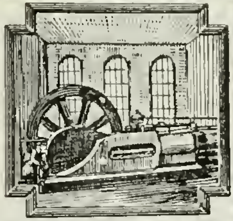
The Dunswart Iron and Steel Works, Limited, turned out 5,355 tons of iron, valued at £123,165 in 1921. A new 3-roll high 18-inch cogging mill is in the course of erection. It is intended later to manufacture steel castings up to 7 tons in weight.

The Witwatersrand Co-operative Smelting Works, Limited, has erected a new plant at Driehoek, to which the old equipment is being transferred. The capacity of the new plant will be 4,500 tons per annum. The 1921 output was 1,296 tons of shoes and dies, worth £25,900, as against 1,201 tons in 1920, valued at £24,020.

It would appear, Mr. Stevenson concludes, that the local industry has not as a whole made the progress that was anticipated, even allowing for the depression period. Whether the new Iron and Steel Industry Enactment Act will prove sufficiently attractive to interest capital is open to some question.



STEAM POWER DEPARTMENT



The Economic Importance of the Power Plant in the Steel Industry[*]

By E. F. ENTWISLE[†]

FROM the inception of the human race, its development has been dependent on its knowledge of and ability to use power. The first manifestation of power was in man's own labor in caring for himself, then in using his power in making others work for him, then the gradually increasing realization that the blowing of the wind, the flow of water, the heat of the fire—all could be used in ways that outdistanced human effort and pointed the way to still greater possibilities of accumulated power. Civilization has progressed as sources and control of power have progressed and today we find virtually every line of human endeavor absolutely dependent on some kind of power not contained within the individual himself, every industry with power the very mainspring of its existence, and in innumerable cases furnished from a source over which the industry itself has no direct control.

From the beginning, the steel industry has had to depend on its own organization for its power, first in human effort in collecting its materials for reduction by natural combustion, then by further human effort applied to the bellows of the Catalan forge, then by the application of water power, by the steam engine and the combustion of natural fuel for steam generation. Afterwards followed the first crude efforts at utilization of waste gases in boilers and blast heating, working up finally to the direct use of the gas in the internal combustion engine, so that with the gradual development of the industry there has been a parallel development in the industry's own power plants.

This has been true of necessity, for at the outset there were no adequate sources of, or means of transporting to the plant, the large quantities of power required, and long before any knowledge of electrical generation and transmission, it was recognized that the sources of power in the industry itself necessitated their utilization at the plant, so that we have today in every steel works a power plant, frequently in many units, generating in all of its several phases most of the power required to carry on the various operations from raw materials to finished steel products.

During comparatively recent years tremendous development has been made in the size, reliability and control of electrical apparatus for steel plant service and in the generation and transmission of the power required for its operation. Its almost innumerable applications need no recapitulation here, but they have been so general in character and large in total that in many cases the development of the plant's own power supply has not kept pace either in economy or size with the peak power demand, so that electric current frequently must be purchased to take care of these maximum load periods. It is only natural to expect that still further applications of power, both electric and steam, will be made in the ever constant development of the steel industry so that its power plant will ever become increasingly important.

How large a factor any one item is in steel manufacture is judged mainly by its percentage of the cost of the finished product. Knowledge of operating costs is essential to economic operation, and the steel plant cost sheets of the present day furnish the executive with the detailed information that enables him to analyze production costs. Every item, raw materials, labor, repairs, transportation, etc., and their relative importance to each other for various products, is constantly before him, and his mind is always concerned in cost betterment, either through rendering labor more efficient, through price reductions, substitution of less expensive or of better materials, or through more economical use of the materials available. Unfortunately, power does not appear on our cost sheets as a single total item and we are apt to think of power costs only to the extent that they do appear as separate items of steam, electricity, water and air, not always remembering that power is the total of all of these, plus the additional power costs that are necessarily included in our cost sheet figures, in raw materials for their handling, in partly worked materials, power for shops appearing as repairs, and many other auxiliary operations.

The result is that the true cost of power is not generally fully appreciated, total power cost being defined as the cost of producing or purchasing all the energy for generating steam, electricity and blast furnace blowing. In such a cost, waste heat must be accorded a value commensurate with the value of the fuel that would have to replace it if the waste heat were not available. While it is true that the value placed on such waste heat is returned as a credit to the cost of the producing department, its real value must be set down as an item of power expense in order to fully appreciate how large an item power actually is in production costs and for a proper realization of the importance of its economic use. However, it is also important to know what portion of power costs occurs from such waste gas and heat charges, and it is advisable that these charges be so accumulated that their effect on costs can be properly judged.

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[*] Paper read before the American Iron and Steel Institute, at New York, October 27, 1922.

[†] Assistant General Manager, Steelton Plant, Bethlehem **Steel Company, Steelton, Pa.**

The data submitted has been taken from the cost records of three of Bethlehem's steel plants and covers the period from January 1, 1920, to August 1, 1922. It is felt that this period is fairly representative of modern practice, 1920 being a year of good production, but with many war time prices and practices still continuing, 1921 being a year of low production and best possible economy, and 1922 being a period of increasing production with a continuance of improvement in the economies of 1921.

	Including value of By-Product Gas and Waste Heat.		Not including any value for By-Product Gas and Waste Heat and with Total Power Consumption figured at Plant producing cost.	
	A	B	A	B
1. Ratio of total power cost to delivered cost of all coal for coking	.82	.60	.60	.28
2. Ratio of total power cost to delivered cost of all gas coal, and oil	1.67	.64	1.22	.30
3. Ratio of total power cost to delivered cost of all ore	.65	.60	.48	.28
4. Ratio of total power cost to delivered cost of all limestone	5.35	2.40	3.90	1.10
5. Ratio of total power cost to delivered cost of all alloys	2.45	2.16	1.80	1.00
6. Ratio of total power cost to delivered cost of all refractories	2.70	2 98	2.00	1.40
7. Ratio of total power cost to total ingot cost	.138	.142	.101	.065
8. Ratio of total power cost to total plant payroll	.255	.230	.187	.106
9. Ratio of total power cost to sales value of all finished products	.071	.080	.052	.037
10. Horsepower hours consumed per ton of shipments	286	242	286	242
11. Kilowatt hours (including equivalent of blast furnace blowing) consumed per ton of shipments	256	516	256	516
12. Per cent of blast furnaces blown by gas engines	100	100	100	100
13. Per cent of Item 10 generated by waste products	39	68	39	68
14. Per cent of Item 11 generated by blast furnace gas	78	72	...	...

It is not necessary to repeat here the individual power consumptions for various products, as we are interested primarily in accumulated power usage and cost. The following tabulation shows the ratio of the cost of total power generation to the costs of some of the principal and more familiar items entering into production costs. From these figures have been eliminated all the effects of such pig iron and coke as were manufactured for shipment to outside customers, so that the data applies generally to any steel plant, the operation of which extends from coke ovens to finished steel products. In the first set of figures, blast furnace and coke oven gas and waste heat are charged to costs at full value. In the second block, all charges for such waste heat products have been eliminated and all power purchased is assumed to have cost the same as the power generated at the plant.

The importance of power as an item in production costs is sufficiently apparent from the preceding tabulation. Any single cost item that, stripped of all credits, reaches the proportion of nearly one-fifth of the total plant payroll, or 5½ per cent of the total sales value of all manufactured products, or twice the cost of all refractories, commands attention. How to reduce it, and the extent to which it can be reduced, constitute the real economic question. Every plant is a problem in itself, and no definite formula can be laid down that is applicable to all. Different kinds of products, different degrees of finish, different seasonal demands and many other variables are considerations that necessarily must be taken into account in determining how much and in what manner power shall be generated. It is undoubtedly true, however, that comparatively few plants are in the same position where their total power costs cannot be reduced and at the same time show a good return on the expenditures required to make the reduction.

In general there are three points of attack on the problem after the cost analysis has been made; first, on the prime movers of mill and auxiliary drives; second, on the electric generating and blast furnace blowing plants; and third, on the steam plants.

Prime Movers for Main Drives and Auxiliaries.

For new installations there is little room for argument against electrification as showing the greatest economy. For existing steam-driven units practically every case will show a fair return on the investment by the substitution of electric drive, including the generating equipment. Some improvement can often be shown by the substitution of more economical types of steam drives, but aside from other considerations, it is obvious that the tremendous handicap of the miles of steam piping required for a steam operated steel plant imposes a burden on the steam drive which it cannot carry in competition with the electric drive.

The Electric Generating and Blast Furnace Blowing Plants.

It is not contemplated in this paper to discuss the relative merits of the types of drive for this service. Sufficient to say that, in general, steel works have not taken full advantage of the economies possible. The power plants are often scattered in a number of separate installations and the overall efficiency of all power generation is not nearly the possible maximum. Usually the maximum operating load can be carried only by putting uneconomical units into operation, or by purchasing power from an outside source.

Steam Plants.

Here can usually be effected the greatest economies and greatest savings. Steam plants are even more scattered than the electric generating plants. They are nearly always old and in small capacity units. It is probably safe to state that 80 per cent of steel works blast furnace gas fired boiler plants have no legitimate excuse for existence, and many of the coal burning plants are but little better. Steam lines should be eliminated wherever possible, and where they must exist, should have the fullest protection and attention to minimize condensation and leakage losses.

Keeping these three general points in mind it is interesting to return momentarily to the tabulated figures, particularly items 7 to 14, inclusive, as they illustrate to some extent the possibilities referred to.

A is the average of plants in which power requirements are about evenly divided between steam end electricity, while B is a plant which is, primarily, motor driven. While the nature of the products from plant B requires nearly twice the quantity of power per ton than do the products from A, B's power bill per ton is scarcely greater than A's, due to its more extensive recovery of power, proportionally, from its by-product gas and waste heat, and in spite of the fact that 28 per cent of its total electric power must be purchased at a unit cost of about four times its own generating cost, all of its own power being generated by gas engines. Plants A purchase 14 per cent of their electric power consumption. Improvements now under way at B will eliminate this excess burden, and a truer comparison of the accomplishment possible may be seen in the second block of figures, in which gas and waste heat charges have been eliminated and the power now being purchased figured at plant producing costs.

Further reductions in this plant's power costs may be made through the replacement of its existing boiler plants, and it is safe to say that this plant, or any one similar in equipment and power requirements, can reduce its total power bill, eliminating all charges for by-product gas and waste heat, to about 5½ per cent of its total ingot cost.

Returning to the general question of economic importance of the steel works power plant, there are a number of still unmentioned items that must not be overlooked. The investment necessary to accomplish the savings that are shown to be possible by such a detailed analysis is very often a large one and very often the amount is so large that the same investment in added steel capacity, or a different line of product, will yield a larger return than will the power plant. Such a condition very often occurs, and where expenditures must be limited, the power plants have suffered in consequence. It must be borne in mind, however, that every plant addition increases the power plant's responsibility, and while the return may not be of the highest, it is sufficiently attractive to warrant the expenditure, and economically the right thing to do.

The power plant is linked economically with the utilization at highest efficiency of all the by-products of the industry and the plant that strives only to utilize sufficient of its energy producing by-products to carry its own power load is looking backward, not forward Electric power has become of such tremendous importance to the every-day life of our country and its uses are constantly multiplying to such an extent that probably none of us fully realize the power demands of tomorrow. Our country's general system of power generation from coal mine to delivered power has an inefficiency that cannot indefinitely be tolerated, and we are undoubtedly not far from the day of the super-power transmission system, possibly under public service control similar to our rail transportation systems, and under which no industry with power producing by-products may escape the responsibility of contributing them to the general power system. Such an institution will ultimately result in economies to all industry, in reduced cost of power, and to the steel plant particularly, in solving the problem of the best means of supplying the widely separated peaks in both directions, of power demands and supply. Public interest in smoke prevention simply as a convenience has forced economy on many an industry, and the power situation of today offers a similar opportunity, but with the additional weight of public necessity rather than mere convenience.

We cannot help but realize that steel plant operation cannot be, and is not, carried on under the wasteful methods that were common practice not so many years ago. We acknowledge our responsibility in the happiness and welfare of our employes, we acknowledge our responsibility in the economic structure of our immediate communities and of the country, and we cannot be blind to the fact that the not far distant future will impose on us, and rightfully, the problem of converting at highest efficiency all of our waste products into power, to the end that all industry may be benefited by the surplus power thus made available and protected by the resulting conservation of our natural fuel supply.

BRIER HILL STEEL COMPANY PLANS

Engineers of the Brier Hill Steel Company, Youngstown, are continuing their study of the company's expansion program, and directors have not yet approved any program. In addition to adding lap weld tube mills, the company is likewise considering the construction of butt weld units. The lap weld planned will roll pipe from 2 to 12-in. in diameter, though the company has considered units capable of rolling 16-in. pipe. Skelp for these mills will be furnished from the 132-in. plate mill, for the larger sizes, and from a new strip mill, which is to be added, for the smaller sizes.

According to plans now in process, butt weld units may be added to produce wrought iron pipe, absorbing part of the output of the Youngstown Steel Company at Warren. Interests of the Brier Hill company control the Youngstown Steel Company.

REPORTS ON ACCIDENTS IN STEEL INDUSTRY

Accidents in the iron and steel industry decreased materially in 1919 over the previous year according to a report recently issued by the United States bureau of labor statistics on "Causes and Prevention of Accidents in the Iron and Steel Industry, 1910-1919." According to this report the number of accidents decreased in 1914-1915 over 1913 due to the decline in the number of men employed. Employment was increasing from May, 1915, to December, 1917, the accident rate for the same period showing an incerase. A decline started at this time and was in progress at the close of 1919.

Each of the chief causes of accidents, such as machinery, falls, etc., are presented in such a way as to show clearly the relative conditions in the various departments. Considering machinery as a cause of accident, it was found that the electrical department stands at the head of the departments in which there were injuries. The open hearths were second and the fabricating department third under this classification. It was also found that under the classification of hot substances and falls of workers, the electrical department stood first in the number of accidents.

The report also contains a discussion on method to be used by the safety man in the prevention of accidents.

Underfeed Stokers Burn Low Grade of Coal

Underfeed Stokers Specially Designed to Burn Low-Grade Fuel Installed Under 5,600 Sq. Ft. of Boilers—Plant Operates at High Rating and High Efficiency.

By C. E. REESE[†]

THE boiler plant of the Sixth Avenue Generating Station of the Twin City Rapid Transit Company, Minneapolis, Minn., contains twenty-eight 5,560 sq. ft. boilers, all originally fired with chain-grate stokers and burning a low grade fuel.

This station supplies current to an electric railway system and operates in parallel with several hydro-electric plants which are kept constantly loaded to the limit of the available water supply, consequently this station is required to take care of the stand-by and the wide fluctuation in the railway load, which makes the requirement somewhat severe in both capacity and efficiency incident to the demands of a station operating on this class of service.

Fig. 1—Boiler room firing aisle.

Several years ago it was decided to increase the capacity of the boiler plant and to improve its flexibility and economy. In view of the kind of coal being used, considerable doubt was expressed at the possibility of accomplishing the desired result with any type of underfeed stoker then available, for the problem of continuous and satisfactory combustion of clinkering coals of low grade, high in ash, moisture and sulphur, had not up to that time been completely solved.

The increase in capacity was, however, successfully accomplished by redesigning the setting of six boilers and replacing the chain-grate stokers with specially designed ones of the underfeed type and has made possible the operating of the boiler up to 350 per cent of rating, thereby materially increasing the capacity of the boiler plant.

The boilers on which the alterations were made are B. & W. water tube, 13 tubes high, 21 tubes wide and of 5,560 sq. ft. heating surface with 900 sq. ft. superheating surface and no economizers. The stokers installed are Westinghouse six-retort underfeed, 10 ft. 8¼ in. in width, 10 ft. ⅞ in. in length, set flush with the boiler front. As the bottoms of the front tube headers are only 8 ft. above the floor line, it was necessary to set the stokers 3 ft. below the floor level to secure the desired furnace volume of approximately 1,300 sq. ft.

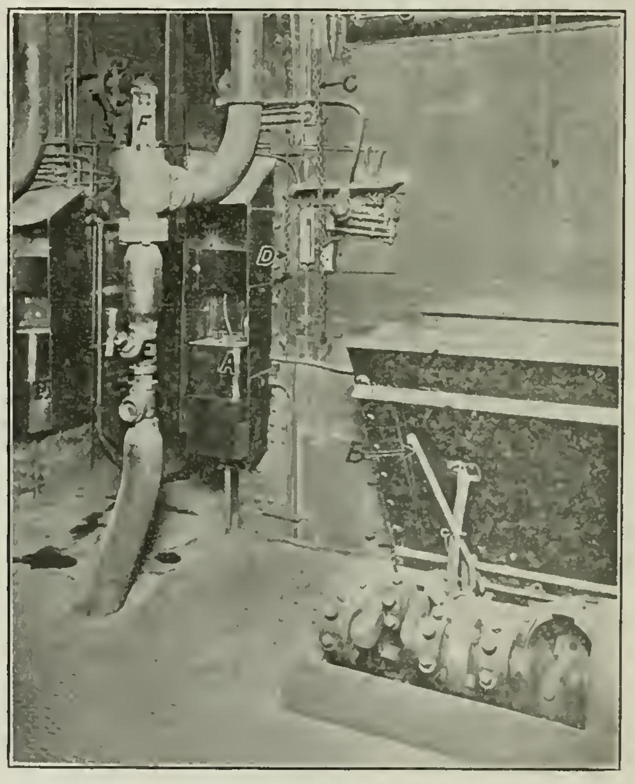

Fig. 2—Control equipment. A—Stoker speed controller. B—Lever regulating length of stroke of secondary ram. C—Uptake damper control. D—Forced draft control. E—Feed-water valve. F—Feed-water flow indicator.

The steam conditions at which the boilers operate are 190-lb. gage and 100 deg. F. superheat at nominal rating.

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[*] Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Stokers of Special Design.

For the proper combustion of the low grade fuel used, several new features were developed and incorporated in the design of the new stokers. The fuel as it is introduced from the retorts by the rams is spread laterally by deflecting plates so as to cover the surface of the tuyeres. The action of these plates also loosens the fuel which, when containing large percentages of moisture and dirt, becomes densely packed under the action of the rams. Secondary step-shaped rams, located midway between the deflector plates and the grate tuyeres, insure a continuous movement of the fuel bed. These rams under independent control extend their action practically to the dump grate, filling in blow holes which may start and also building up the fuel bed to a uniform thickness. Thus the auxiliary rams furnish means for controlling the distribution of coal over the fuel bed and for agitating slightly the lower fuel bed. At the same time all grate surface is made effective for combustion. Thus it is seen that a fuel bed of uniform thickness is made to travel steadily toward the rear. In practice the stoker has been found to maintain these conditions.

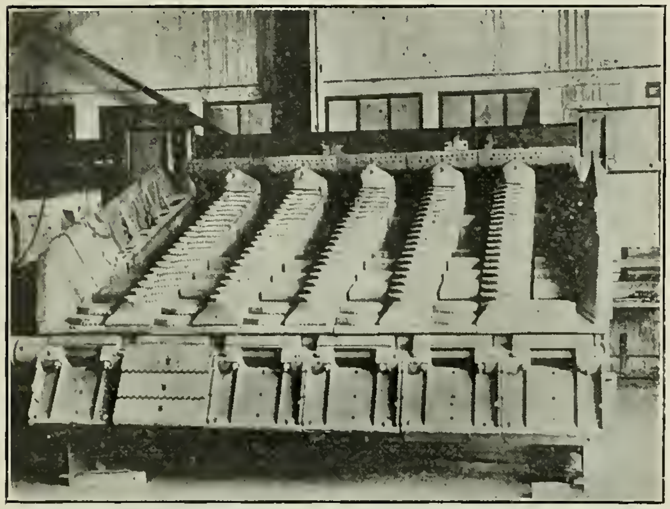

Fig. 3—View of stoker in course of erection.

Adjustment of Secondary Rams.

The length of the stroke of the secondary rams is regulated by one adjustment lever. On the upper end of the auxiliary ram driving rod is a block with four notches, which is engaged by a pin driven through a fixed stroke by a series of links from the primary ram. According to which of the four notches the pin engages, the lost motion of the link movement is taken up so as to vary the stroke of the secondary ram from zero to 6 in. The control of the lost motion is effected by the use of a selector block which slides under the pin and prevents it from engaging any but the desired notch. The details of this construction are shown in the cross-sectional view of the stoker.

To protect the front and side walls adjacent to the fuel bed and prevent the formation of clinkers at this point, extension tuyeres were used. These extend approximately to the top of the fuel bed. Both the side-wall tuyeres and front-wall air boxes admit a limited amount of air underneath and near the surface of the fuel bed, tempering the gases and forming a cool blanket over the lower furnace walls. The reduced temperature in that region is helpful in protecting the brickwork. A battery of high-velocity steam jets placed in the front wall about 18 in. above the fuel bed surface and directed parallel to that surface, insures complete combustion by thoroughly mixing the gases before they enter the tubes. These jets also divert the gas flow toward the back wall of the furnace, providing for a sweep of the gases over the full length of the exposed boiler tubes.

For the discharging of clinker and ash at the rear end of the grate, duplex dump plates are provided, one of which is hinged to the lower end of the stoker and the other to the rear wall support. Each is actuated by an individual steam ram located on the outside of the boiler setting. The stroke of these rams can be controlled by the setting of a collar on the piston. The front dump grate, by its lifting action, may be used to break up clinkers as they pass to the rear dump and also to hold back the fuel bed when the rear dump is dropped. Air for combustion is supplied under control to both front and rear dump grates. This auxiliary air supply enters through a duct enclosed in one of the steel members that support the lower end of the bridge wall. The entire grate surface thus becomes active when required and the carbon is burned down to a low percentage of the refuse before dumping. Also ashes may be dumped frequently on heavy loads without interfering with the output or efficiency, and refuse is disposed of before it builds up into large clinkers.

Changes Made in Baffling.

With the increase in boiler capacity that would be obtained by the installation of the underfeed stokers, considerable change was made in the boiler baffling. It was designed to give practically a constant gas velocity by increasing the cross-section of the passes in the same ratio that the gases contract due to the abstraction of the heat by the tubes. The bridge wall and baffling are so located as to expose 90 per cent of the tube length, giving a tube area double that of the grate to absorb heat by the direct radiation from the fire. The bridge wall rises from the dump grate to a level with the surface of the rear of the fuel bed and then recedes to the rear, meeting the tubes at the back end of the boiler. With this condition of tube exposure, it is estimated that over 50 per cent of the total heat is absorbed in the first two rows of tubes. The high heat absorption directly by radiation accounts largely for the low furnace temperature and consequently a minimum of clinker formation. Before dropping on the bucket conveyor, the ashes must pass through an 8x8-in. cast iron grid. If

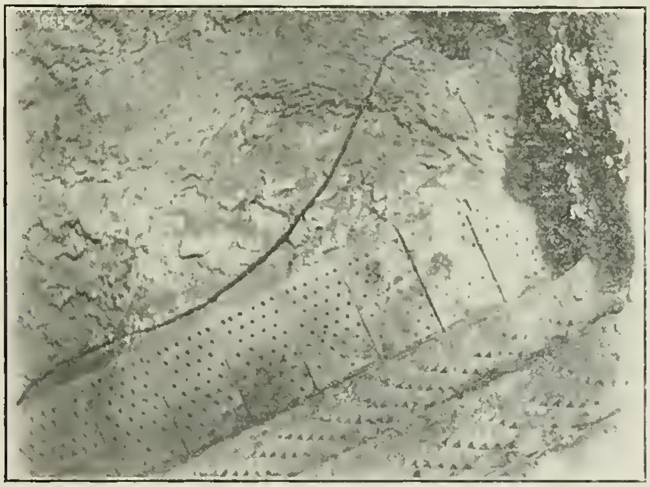

Fig. 4—Showing side wall tuyeres.

there was excessive clinkering, this system would be objectionable because the refuse would have to be reduced to the proper size before it could be handled by the conveyor.

With the installation of the new stoker and the redesigning of the furnace, the angles of the stoker, the front and bridge wall are so arranged that the radiant heat which does not enter the tube surface directly reaches the boiler with but one reflection. Such a condition means that the maintenance of furnace walls and other brickwork is considerably lowered by the elimination of double and triple reflections. After 18 months' operation the furnace settings have required no repairs of brick linings and there is practically no accumulation of slag on the walls.

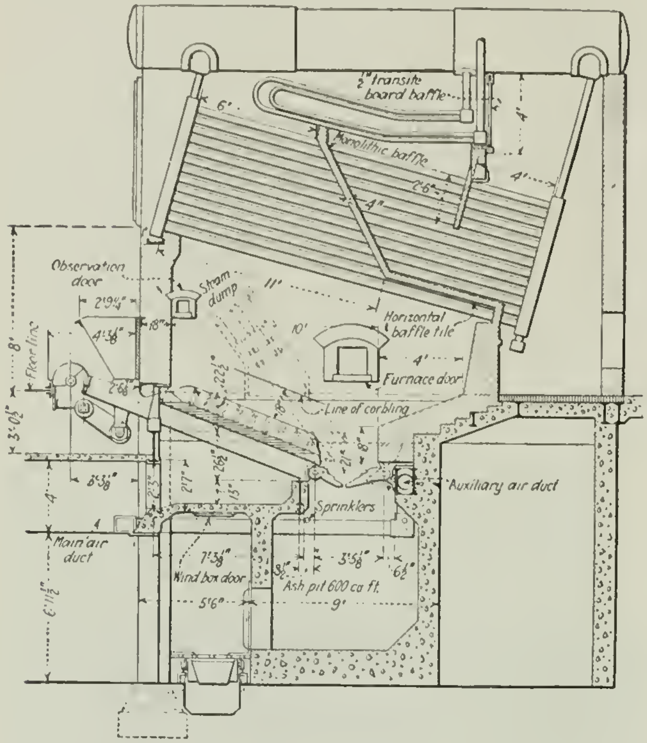

Fig. 5—Section showing details of stoker.

The area of the superheater surface was increased approximately 63 per cent, as it was estimated that the temperature of the gases as they entered the second pass would be considerably lower than formerly, owing to the heat absorbed directly from the fuel bed by the first two rows of tubes, and to the change in the baffling. The superheater, consequently, was lengthened so that the bends extended over the first pass instead of merely up to the first baffle. This gives the effect of a double-pass superheater. Its area was increased from 550 to 900 sq. ft. by this extension to be sure that at least the same superheat would result. When operating at about 170 per cent of rating, the superheat formerly averaged about 100 deg. F. and the chart, Fig. 6A, shows how it was increased to 140 deg. F. at this rating and also how it continued to increase as the boiler was forced to higher ratings.

The construction of the rear baffle as worked out made it unnecessary to utilize the superheater headers to support the baffle tile. Instead of baffle tile in that position, between the lower superheater headers and the boiler drums, ½ in. Transite board has been used. It is secured between two "L" holders, the upper one being hung from ⅞-in. rods passing over the boiler drums. The lower one is built into the section of tile baffling resting on the upper rows of boiler tubes. Seven sections, 21 in. by 4 ft., are required per boiler, each section being reinforced vertically with an angle and a channel. The advantage of this type of construction is that the baffling is readily removable and that it is independent of the expansion and contraction of the superheater risers.

By referring to the boiler record chart, Fig. 7, it will be seen that the equipment has demonstrated the possibility of operating at any capacity up to 350 per cent of rating. At this high rating low grade fuel is burned at a rate of one ton per retort per hour, and the refuse is disposed of with no excessive loss of carbon or loss of capacity or efficiency while dumping. Whether this high rating is the limit of the stoker capacity has not yet been determined, for the rate of evaporation was limited by the capacity of the feed pump and the feed line to supply the boiler with water.

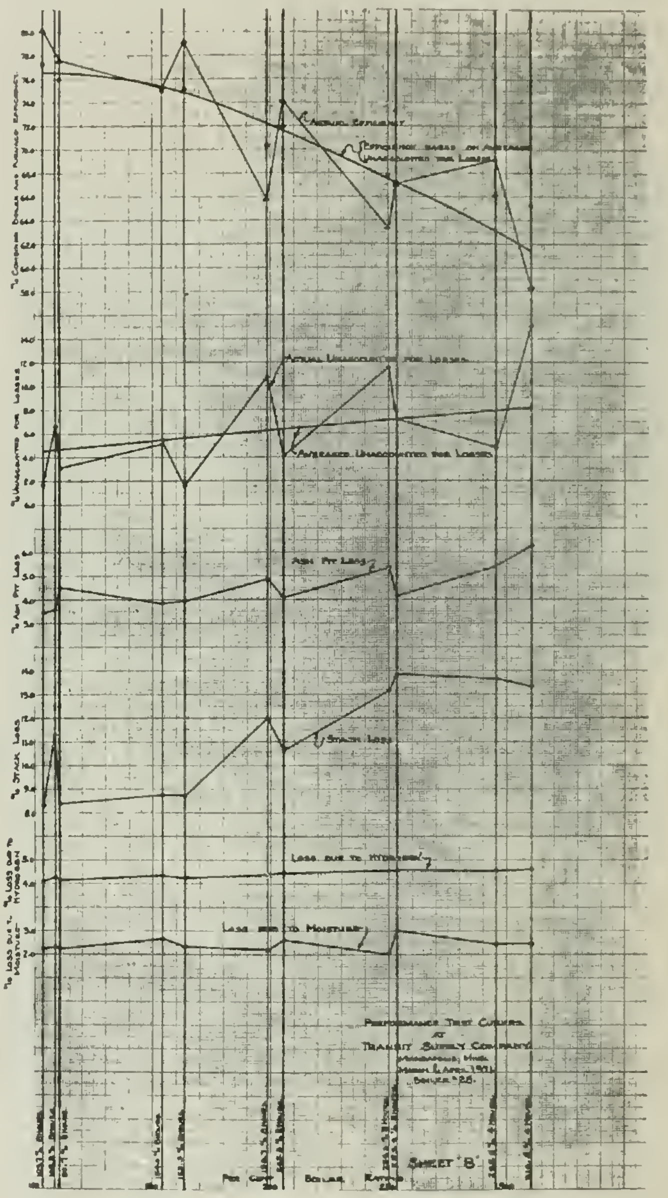

Fig. 6—Performance test curves at 100 to 350 per cent rating.

This design of stoker and furnace has demonstrated other advantages. It is possible to control the air supply to the most efficient proportions, little if any slag is formed on the furnace wall, and the highest efficiency is secured at or near normal rating. The stoker maintenance has been low and the percentage of combustible in the ash has been reduced to a negligible proportion.

In Fig. 6 are shown the curves that were obtained from a series of 12 tests, at outputs ranging from 100 to 350 per cent of rating, conducted under the direction of E. H. Scofield, engineer of power, and by representatives of the Westinghouse Electric & Manufacturing Company and of the Twin City Rapid Transit Company. The fuel characteristics and operating conditions varied as outlined in the following tabulation, the result of each test being reduced to a basis of conditions shown in the third column:

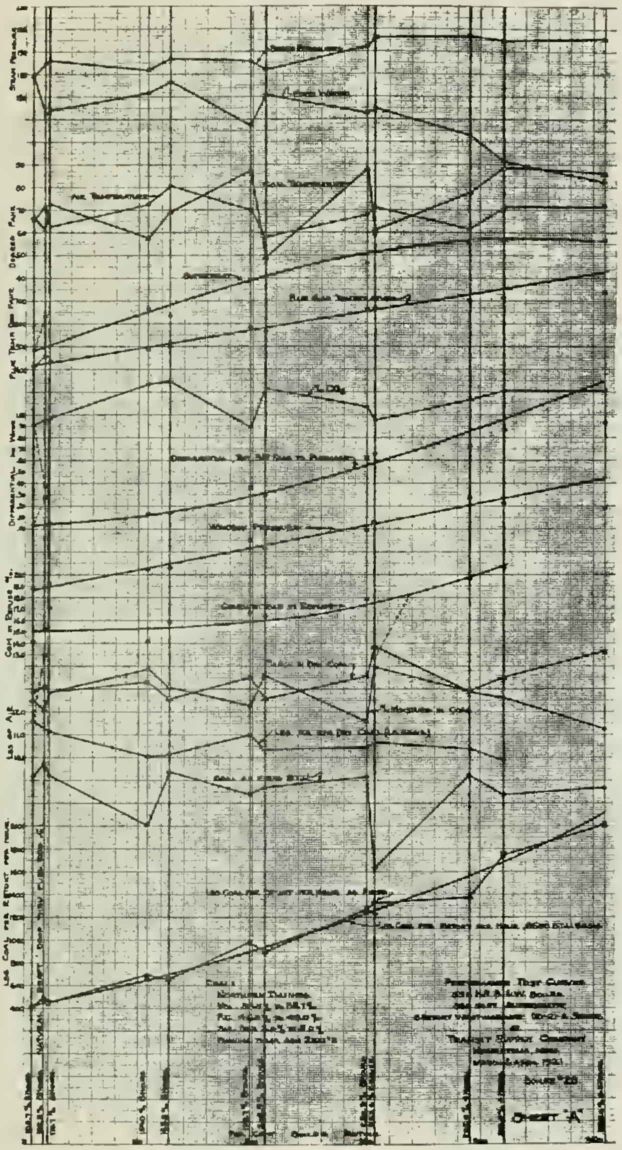

Fig. 6A—Performance test curves at 100 to 350 per cent rating.

Coal—	*Minimum*	*Maximum*	*Curve Basis*
Moisture, per cent	14	20	18
Ash, per cent	16	22	18
Sulphur, per cent	3.5	5	4
Volatile, per cent	32	35	33
Fixed Carbon, per cent	45	48	45
Ash fused, at deg. F.	..	..	2100
Btu. commercial	8827	9750	9550
Btu. dry	..	..	11650
Btu. combustible	..	..	14200
CO_2 at top of third pass, per cent	13.5	15.5	14–15
Carbon in refuse, per cent	13.0	20.0	15–20
Uptake temperature, deg. F.	415	740	400-750

While the efficiencies on test range from 77 per cent at normal rating down to 60 per cent at 350 per cent of rating, the average operating economy is placed at about 70 per cent. Considering the wide and sudden variations in load and the character of the fuel, this performance is excellent. It may be compared to an average of 60 per cent for the old installation.

That considerably better results can be expected with a higher grade of fuel was indicated by four tests made at loads ranging from 200 to 275 per cent of rating with Harrisburg screenings of the accompanying analysis. The results are indicated by the squares in Fig. 6.

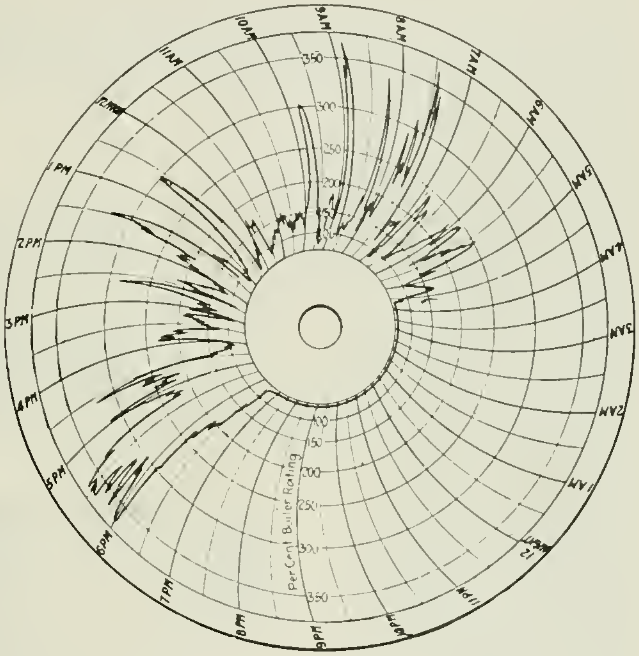

Fig. 7—Per cent boiler rating developed.

ANALYSIS OF HARRISBURG SCREENINGS

Combustible	77.87
Moisture	9.90
Ash	12.23
Volatile—dry coal	29.48
Fixed carbon	54.11
Sulphur	2.81
Ash	13.60
Btu. commercial	11,304
Btu. dry coal	12,541
Btu. combustible	14,514

During the 12 tests no large clinkers were formed at any time, no slice bar work was required on either side wall or bridge wall, and no slag formed on the furnace walls or boiler tubes. The dumping periods were frequent and there was no appreciable drop in the percentage of CO_2 or in the steam flow. Such furnace conditions provide a unit of great flexibility peculiarly adapted to stand-by and intermittent demands and to meet the most exacting requirements of railway and power loads. They also reduce the banking losses to a low figure, the amount consumed during banked period being around 250 lbs. per boiler hour.

Corrosion Control by Deactivation of Water

Relative Rate of Corrosion—Protective Coatings—Dissolved Oxygen in Water—Oxygen Removal by Chemical Means.

By FRANK N. SPELLER,,* B.A.Sc., Member A. S. M. E.

PART II

TWENTY or more of such plants have been put into operation to protect the hot-water systems of large buildings in the United States during the past two years. There is no practical difficulty that has not been overcome in operating such plants. The residual oxygen may vary from zero to about .75 c.c. per litre during certain parts of the day without doing perceptible damage. It is more difficult to remove the last traces of oxygen which in any case have a negligible influence from a practical standpoint, but when the rate of flow slows down, the oxygen is more completely removed and a large volume of deactivated water is thus available for use at any time. So far, experience indicates that the metal should be removed from the deactivating tank every two or three years, depending on the demands of the system. That which has been only partially consumed may be cleaned and put back with new sheets. Domestic water carries on the average for the year 10 p.p.m. of oxygen by weight which will consume about 0.2 pounds of iron per 1,000 gallons, which represents a saving of that much iron in useful form in the more inaccessible parts of the plant.

Deaeration By Mechanical Means.

Experimental work on oxygen removal at low pressure and high temperatures with which the author has been associated, usually gave an oxygen content lower than the theoretical figure, due to corrosion of the apparatus. With sufficient time and where the water is broken up by spraying or passing over baffles, the theoretical minimum oxygen can always be obtained. Many tests in service have indicated that most of the common types of open feed water heaters when properly vented and operated without excessive load will give approximately the theoretical minimum of oxygen as indicated in saturation curves (Fig. 1).*

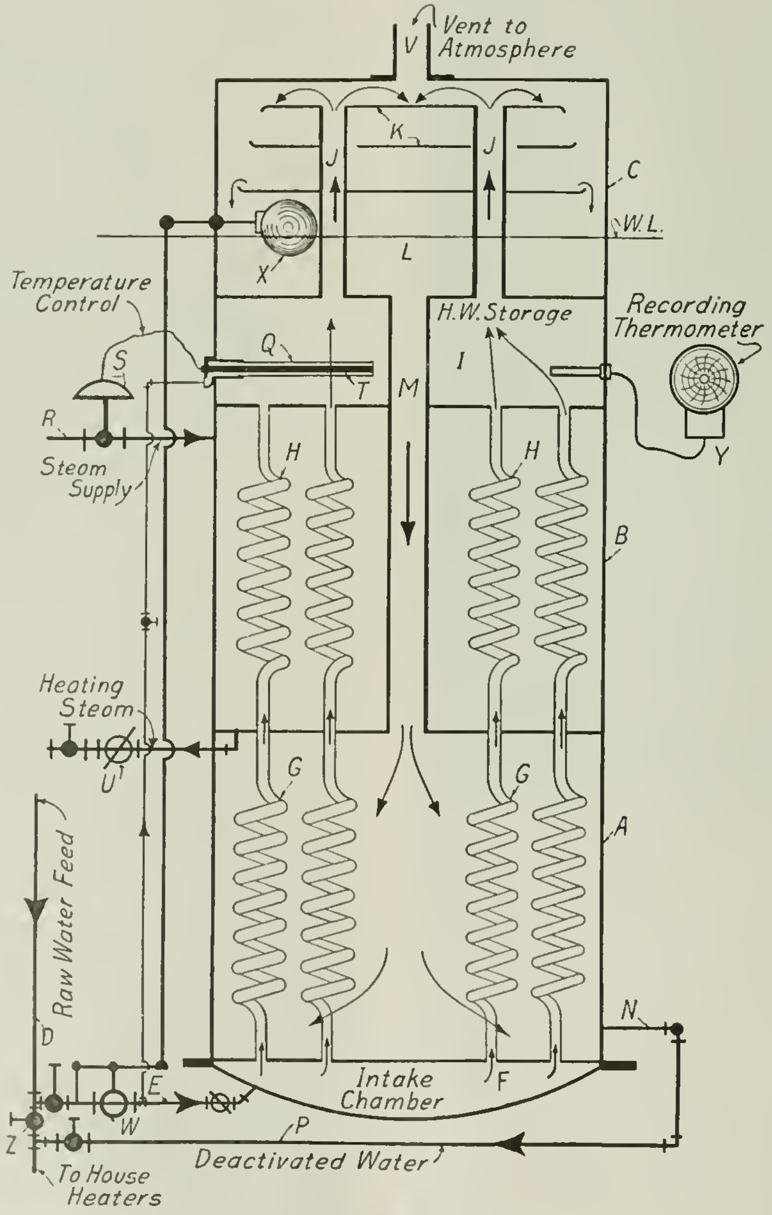

Fig. 9—Deaerator operating at atmospheric pressure.

It is a comparatively easy matter to remove 80 per cent of the dissolved gases by mechanical means but very difficult to remove the last 5 per cent, so that, as in the case of chemical deactivation, before designing a plant it is important to determine what amount of residual oxygen will be harmful under stated conditions. This depends on the temperature, volume of water handled, and other factors, and must be estimated for any particular set of conditions before undertaking the design of deaerating equipment. The deaerating efficiency desired will evidently have much to do with determining the most economical form of apparatus to use. A few types which have been developed and tried out will be described briefly.

Deaeration of Hot Water.

A simplified form of deaerator, developed by the Anti-Corrosion Engineering Company of

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*Communication to the Franklin Institute.

*The Author is indebted to Mr. G. H. Gibson of the H. S. B. W.-Cochrane Corporation, Philadelphia, Pa., for considerable data on this point which were obtained from heaters in operation.

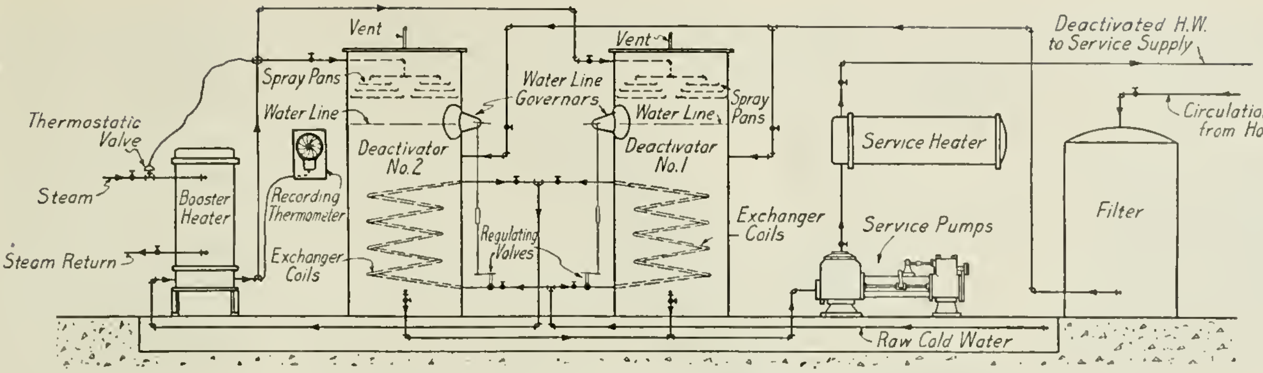

Fig. 10—Deaerators—Passyunk Central Heating Plant, Philadelphia, Pa. (Designed by Anti-Corrosion Engineering Co.)

New York, is shown in Fig. 9. This operates at atmospheric pressure and consists of three essential parts which may be combined in one shell as indicated in Fig. 9. These are: A heater, heat exchanger, and deaerating chamber. An ingenious method of temperature control is provided which is desirable for efficient operation so that the temperature will not vary more than 3 or 4 degrees from 208 deg. F. at any time.

The cold water entering at the point shown near the bottom of the apparatus is partially heated in passing up through the tubes of the heat exchanger by the warmer water coming down. After leaving the heating section, the temperature of the water will be about 208 deg. F. After passing oven baffles of the vented deaerating chamber at this temperature, the oxygen contents are found to be reduced to about 0.4 c.c. per litre, which may be still further reduced by passing through zinc scrap or other deactivating material if desired. Usually, however, this is not necessary.

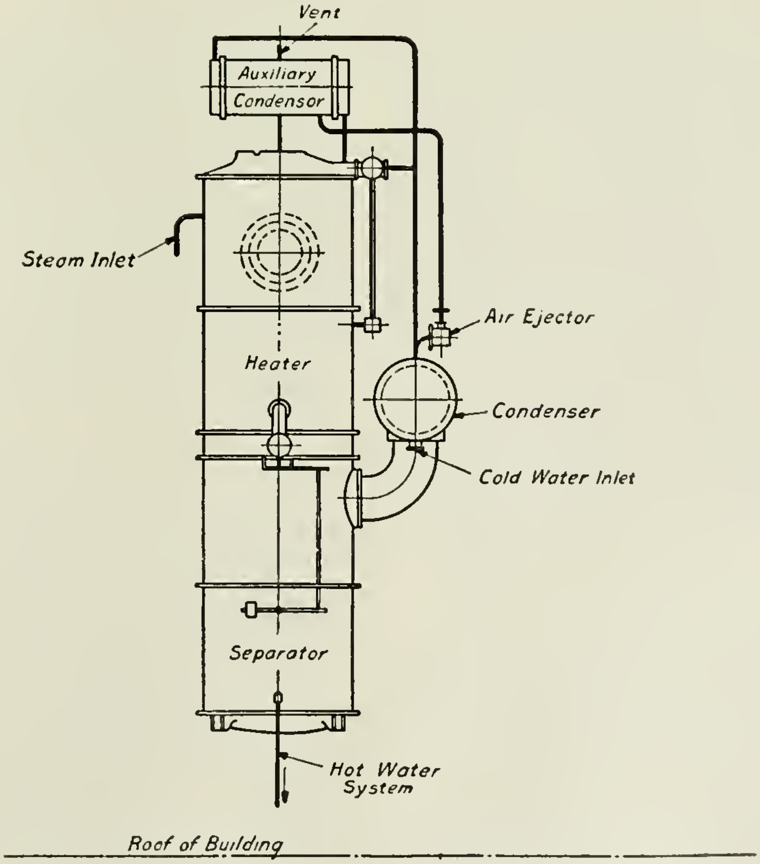

Fig. 11—Deaerator operating at reduced pressure.

Several of these plants have been installed in large buildings and appear to be fulfilling their purpose in a satisfactory manner. This method of removing free oxygen has been designed from experience in high buildings which obtain their water pressure from open stand-pipes placed at a high level. The same scheme has been adapted to cases where the hot water is repumped and recirculated as in the plant installed for the Girard Estate Passyunk Power Plant, Philadelphia, Pa. This plant was described by Robert Hughes, Chief Engineer of the Girard Estate.* It includes a hot-water service system for 500 houses to which the water is pumped through a four-inch wrought pipe with a three-inch return loop. The piping was so badly damaged and clogged by corrosion after 10 years that it was decided to try deaeration. A plant was installed in 1920, on the principle of that shown in Fig. 9, except that the heater was independent of the deaerator and heat exchange units. This plant is illustrated diagrammatically (Fig. 10). The temperature is kept within a range of 194 deg. to 210 deg. the oxygen being thereby reduced to a maximum of 0.5 c.c. per litre. They report that corrosion has been brought under complete control and the old rust and scale in the piping removed to a large extent. The removal of the hard rust after the oxygen contents of hot water have been reduced at about 0.5 c.c. per litre is a very interesting and unforeseen development which was observed in the first deactivating plant installed by the author in 1915. The disintegration of this old rust is perhaps due to dehydration or may also be due to a reduction of some of the ferric hydroxide to a lower hydroxide which is more soluble.

Another type of mechanical deaerator has been designed and built by W. S. Elliott, one form of which for large buildings is illustrated (Fig. 11) which operates as follows: Raw water is taken from the supply line and conducted through the cooling circuit of the main surface condenser, which is designated in the diagram as "condenser." From the surface condenser the water passes to the heater, the flow of the greater portion of it being controlled by the inlet valve of the heater. A small portion of the water is by-passed to the heater through the cooling circuit of a small surface condenser, designated as an "auxiliary condenser," the function of which is to condense the steam used in the air ejector and recover the heat.

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*Journal Am. Soc. H. and V. Engrs., March, 1921, p. 107.

From the heater the water flows by gravity to the separator, the rate of flow being controlled by the inlet valve of the separator. In the separator, the air is removed by suddenly introducing the heated water into a region of vacuum in which the vapor pressure corresponding to the vacuum is lower than that corresponding to the temperature of the entering water. The water boils explosively, its temperature is lowered to the temperature of the vacuum and the dissolved gases separated. Some portion of the water is evaporated into steam in the separation process and the rest of it flows into the service pump line. The portion which has flashed into steam, mixed with the separated gases, is drawn into the surface condenser which is attached to the separator shell where the stream is condensed and the condensate returned to the separator; the heat of the stream is returned to the cooling water, and the non-condensable gases are removed by steam jet air ejector. From the separator, the hot deaerated water is delivered to the hot-water service line.

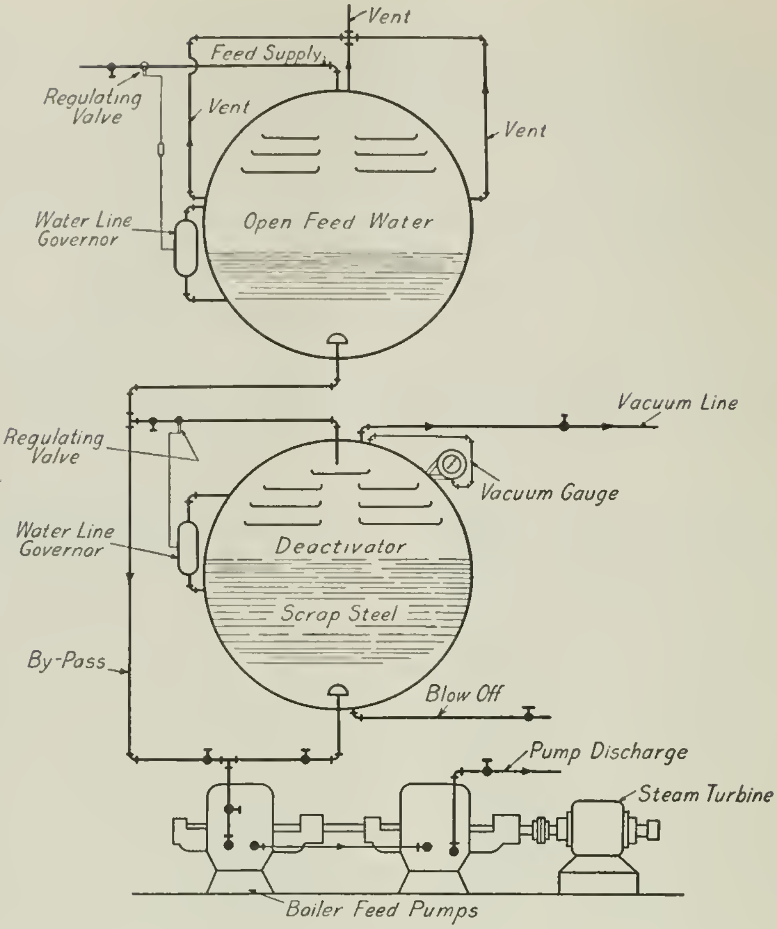

Fig. 12—Combined deaerator and deactivator for boiler feed water.

When correctly designed and operated at the proper rate, it is reported that very low oxygen contents can be obtained with this apparatus. It would seem that this form of deaerator is one that would be best adapted for larger power plant work, for instance where it is necessary to keep the oxygen contents of large quantities of feed water below 0.2 c.c. to preserve steel economizers. One has been installed quite recently in the Delaware plant of the Philadelphia Electric Company.

Deaeration of Cold Water.

Water at normal temperature usually has a comparatively low rate of corrosion and does no serious damage to galvanized pipes within 20 or 30 years, but there are exceptional locations where the cold water is more active or where the corrosion which does occur causes considerable inconvenience through clogging of the system with a bulky form of rust.

Then again cold salt water is more active than fresh water and causes considerable damage in the seaside hotels, bath houses, and in large condensing plants. Such corrosion can usually be reduced to a negligible amount by deaeration. The process of deactivation by steel scrap is usually too slow and therefore not economical for water at normal temperature, so that for such conditions we are forced to use a high vacuum aparatus. By reference to the diagram, Fig. 2, it will be seen that with a vacuum of 23 inches of mercury, about 80 per cent oxygen removal may be accomplished with water at 65 deg. F., which is as much as should be needed; in fact, a much lower percentage deaeration would, no doubt, suffice in most cases.

Incidentally it may be of interest to note that deaeration has been usefully applied to cyanide solutions used in the extraction of gold. In 1916 Thomas B. Crowe patented a "Process of, and Apparatus for, Precipitating Materials from Solution" (U. S. Patent Nos. 1,281,249 and 1,321,985), in which the essential element is the deaerating of the gold cyanide solution by means of a vacuum deaerator before the solution is treated with zinc for the precipitation of the gold. Removal of the dissolved oxygen from the solution prevents the formation of zinc oxide, which is said to save about 50 per cent of the zinc and cyanide formerly used. The Crowe Process, as it is now called, was first installed at the Portland Mill at Colorado Springs, Colo., but has since been put in use at other mills in the United States and abroad. The chemical reaction taking place in precipitating the gold may be represented as follows:

$$\begin{gathered} KAu(Cn)_2 + Zn + H_2O = \\ Zn(Cn)_2 + Au + H + KOH \end{gathered}$$

When dissolved oxygen is present, it has been found that zinc oxide is formed and that considerable excess KCn is required to completely precipitate the gold.

Deaeration for prevention of corrosion of a 30-inch steel main at a maximum temperature of 85 deg. F. has been successfully applied on a large scale in the Coolgardie Mining District, Western Australia.* This water, which is highly corrosive, is sprayed into a chamber under high vacuum. After operating for a few years, the results show that the deaerator extracts about 80 per cent of the dissolved oxygen and the corrosion activity is reduced by this means to about one-quarter of the original amount. The residual oxygen is removed after passing through about 30 miles of this pipe, after which the corrosion is reported to be negligible from observations made on steel test pieces. This water carries a small amount of magnesium chloride otherwise corrosion would, no doubt, be still further reduced by deaeration.

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*A description of this apparatus is found on pages 83 and 84 of a paper by O'Brien and Parr on "The Coolgardie Water Supply," Ins. of C. E., vol. 205, Session 1917-1918, Part I.

European Practice In Mechanical Deaeration.

Mr. G. Paris, in his paper on "Corrosion of Iron and Its Suppression by the Degasifying of Water,"* gives the most complete account which has yet been published of work which has been done on this problem in Europe, most of the practical end of which has been done during the past few years. He points out the drawback of degasification under high vacuum due to the difficulty of holding the vacuum in apparatus of a large size and that the minimum oxygen content is limited by the saturation point of water for any particular temperature and pressure. Evidently his experience has not been so favorable as we have found with apparatus of this class.

Several types of open feed water heaters, and deaerating apparatus, are described for extracting excess gas from water under pressure, with some new devices for separating gases mechanically from hot water under vacuum. The laws of solubility of gases in water indicate that to attain sufficiently low oxygen to prevent corrosion, the temperature should be at or near the boiling point for any particular pressure which in practice requires a prohibitive temperature, where the pressure is high, so that it has been found most economical to work deaerators at atmospheric pressure or lower.

The apparatus made by "Balke," of Bochum, Germany, for the extraction of gases from hot or cold water seems to have given good results. The water at normal temperature is violently sprayed into a chamber carrying a 90 per cent vacuum, the disengaged gases being drawn off by an air pump into a condenser. The following results have been published in Mr. G. Paris' paper (ibid):

	Amount of O_2 in cu. cent. per litre.		Amount of CO_2 in cu. cent. per litre.	
	Degasification			
	Before	After	Before	After
Installation of 50 cu. metres, 90 per cent. vacuum, average temp. 20 deg. C.	11.56	0	1.34	0
Installation of 50 cu. metres, 90 per cent. vacuum, average temp. 26 deg. C.	8.6	0.03	19.65	0

The Coolgardie deaerator operating with water at a maximum temperature of 85 deg. F. is reported to give over 80 per cent extraction of gas at high vacuum. The residual oxygen reported with the Balke apparatus operating cold seems altogether too low to be attained under conditions described.

The "Balke" apparatus for degasifying hot water, several of which are reported to have been built, consists of: A horizontal tank with transverse vertical partitions so arranged as to cause the water heated by steam in the first compartment to pass up and down through a circuitous course. The gases given off are collected by a manifold connected to the top of each compartment into a common main. It will be seen that this is practically an open type feed water heater. The treated water is passed into a closed tank where it is kept out of contact with air by an atmosphere of steam or nitrogen. The following results are reported operating at 100 deg. C. (ibid.):

Installations	Amount of O_2 in cu. cent. per litre.		Amount of CO_2 in cu. cent. per litre.	
	Degasification			
	Before	After	Before	After
Centrale Electrique de Treves.	10.50	0.22	1.13	0.00
Mine Adolphe	6.56	0.00	5.00	0.40
Westerwald	5.90	0.00	1.50	0.00

Combination of Mechanical and Chemical Deaeration.

It is obvious from the laws governing the solubility of gases in water and experience with deaerators built on this principle, that the percentage of oxygen removal possible is limited to the theoretical saturation point of oxygen in water at any particular temperature and pressure, whereas chemical deactivation when given sufficient time will go on at any temperature and pressure until all the available oxygen is exhausted. It would therefore seem that where very large volumes of water have to be completely deaerated, or nearly so, an economical type of apparatus would be one in which the bulk of the free oxygen, which is easy to remove, is extracted by some simple and economical form of deaerator and the residual oxygen, say the last 5 or 10 per cent, by chemical treatment. The latter may be accomplished by a few minutes' contact with a suitable form of sheet iron scrap or by reaction with ferrous hydrate from the addition of ferrous sulphate and lime. The action of ferrous hydrate is almost instantaneous but requires a reliable proportional feed of reagents. The combination of sheet iron deactivator with a preliminary deaeration has been employed in treating the hot water of one of the largest apartment houses of New York (Park Avenue and 48th Street). The water for the hot-water supply system is first put through a deaerator of the type shown in Fig. 9, located a little below the stand-pipe on the roof, and is then brought down to a steel deactivator in the basement before entering the system. This gives almost perfect protection to the hot-water pipes. Another design for a combination plant for power plant service is shown in Fig. 12* which includes an ordinary vented open type heater from which the water is passed into a tank at lower pressure but not so low as to boil the water, so that no condenser is required. The residual oxygen amounting to about 0.5 c.c. per litre is finally extracted by passing through steel scrap placed in the lower part of the vacuum tank. A vacuum control apparatus is attached.

Conclusion.

From this outline of the present status of corrosion prevention by deactivation and deaeration of water, the reader may gather some idea of the important application of these principles to the conservation of iron and other metals in closed systems—for what has been said of the protection afforded to iron applies equally well to brass and other metals which are subject to attack by water. As a rule, cold water does not seriously attack pipes or tanks in the life of a building or pipe line, but there are notable exceptions to this rule. The experience with the Coolgardie (West Australia) 30-inch pipe line and the satisfactory results of par-

TABLE I

Summary of Results of Investigations of the Corrosion of Wrought Iron and Steel Pipe in Hot Water Supply Service.

Time Removed	Where Test Was Made	Length of Time Pipe Lines Were in Service	Authority and References	Number of Cases on Record	Average of Deepest Pits, Inches		Conclusions
					Wrought Iron	Steel	
1921	West 41st St. Public Baths, New York City.	4 yrs., 6 mos.	Charles Baskerville, Prof. of Chem., College of the City of N. Y. Reported June 22, 1921.	Fourteen sections of steel of three different makes, 6 sections of wrought iron pipe.	0.0592	Lot (1) ....0.0497 Lot (2) ....0.0535 Lot (3) ....0.0544 Average 0.0525	"Wrought iron showed deepest pitting. Appearance of corroded surfaces was characteristic — wrought iron showing isolated 'pits', steel, a more general corrosion with 'flakes' well distributed with more or less uniformity. The more uniform corrosion of the steel is a fact of no little importance."
1921	West 41st St. Public Baths, New York City.	10 years		Five sections of steel, one section of wrought iron pipe.	0.0606	0.0532	
1921	William Penn Hotel, Pittsburgh, Pa.	4 yrs., 7 mos.	Jas. O. Handy, Dir. Special Investigations Pgh., Testing Lab. Reported July 11, 1921.	Four sections each of wrought iron and steel pipe.	0.1095	0.094	"Such differences, which confirm previous tests, are conclusive as to the relative resistance to corrosion of steel and wrough iron pipe in hot water lines."
1919	Irene Kaufmann Settlement, Pittsburgh, Pa.	2 yrs., 7 days	James O. Handy, Technical Director, Pittsburgh Testing Laboratory. Report made to Resident Director Teller, Jan. 22, 1920; p. 97, Jan., 1920, A. S. H. & V. Engrs.; p. 276, Mar., 1920, A. S. H. & V. Engrs.	Fifteen lengths of steel, 15 lengths of wrought iron arranged alternately.	0.1144	0.1095	"These figures show that no marked distinction is possible between the rate of corrosion of the steel and the iron pipe."
1919	Harvard University Cambridge, Mass.	3 yrs.	Melville C. Whipple Prof. of San. Chem., Harvard University. Jrn'l New England Water Wks. Assn., p. 42, Mar., 1920.	Two sections each of scale-free (steel); galvanized steel, copper steel and wrought iron pipe.	0.073	Scale-Free 0.045 Copper Steel 0.068 Galvanized 0.078	"Judging from the depths of pitting and the general appearance of the inside of the pipe, it was evident that so far as the conditions of this particular experiment with the Cambridge hot water service were concerned, scale-free pipe had suffered less real damage than any of the others after three years' exposure."
1918	Brown University, Providence, R. I.	11 mos.	Wm. F. Kenerson, Professor of Mechanical Engineering, Brown University. Report made June 7, 1918. Bulletin 2 — "Corrosion of Hot Water Piping." National Tube Company.	Two sections each of black and copper steel and wrought iron; one section each of galvanized and copper steel, galvanized.	0.0674	Black Steel 0.0544 Copper Steel 0.0639 Galvanized 0.0547 Copper Steel Gal. 0.0938	"There is evidently no marked superiority of either the wrought iron or steel for the test conditions described. . . . The wrought iron failed first by developing the deepest pits. The steel developed a greater number of shallower ones."
1917	This test was conducted in four different places as follows: (A) West 41st St. Bath, New York. (B) East 76th St. Bath, New York. (C) East 109th St. Bath, New York. (D) Cherry and Oliver Sts. Bath New York.	(A) 2 yrs., 9½ mos. (B) 2 yrs., 5 mos. (C) 2 yrs., 6 mos. (D) 2 yrs. 6 mos.	James S. Macgregor, Instructor in Civil Engineering, Columbia University. Report made Jan.-March, 1917. Bulletin 2 — "Corrosion of Hot Water Piping." National Tube Co.	(A) 3 sections each of wrought iron and steel pipe. (B) 4 sections of steel and 2 of wrought iron. (C) Same as test B. (D) One section each of steel and copper steel.	(A) 0.057 (B) 0.075 (C) 0.035	0.052 0.070 0.035 (D) Steel 0.021 Copper Steel 0.022	Taking the total averages of steel (which include scale-free and copper steel, as well as ordinary black) pipe as against those for iron in the four tests, we find the latter to have pitted deeper by 0.025 in. which indicates in favor of steel pipe in these particular tests.
1916	Irene Kaufmann Settlement, Pittsburgh, Pa.	10 mos.	Jas. O. Handy, Technical Director Pittsburgh Testing Laboratory. Report made October 31, 1916. p. 125, 1917 Trans. of A. S. H. & V. Engrs.	Seven sections of steel and 4 of wrought iron pipe.	0.116	0.110	The author states that a certain sample of wrought iron showed the most general corrosion, while a steel section showed the greatest number of seperate pits. No direct reference to comparative corrosion is made.

tial deaeration show that this method of protection can in some cases be economically applied to cold water when necessary. This would seem to apply particularly to cold as well as to hot salt water used in large seaside hotels, which cause considerable damage and costly repairs. While the laws underlying corrosion are now fairly well established, the economic application of these laws require a detailed knowledge of existing conditions interpreted in the light of previous experience as in all engineering developments. Much yet remains to be done in perfecting details, but the results already obtained are sufficient to indicate the permanent benefits to be derived through the application of these principles.

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†Chemie et Industrie, July, 1921.

*Designed by the Anti-Corrosion Engineering Company, New York, U. S. A.

AMERICAN ENGINEERING STANDARDS COMMITTEE HANDLING 106 PROJECTS

The growing interest in standardization on the part of almost every American industry is emphasized by the quarterly report of the activities of the American Engineering Standards Committee issued from the headquarters of the Committee at 29 West 39th Street, New York City.

Of the projects which have official status before the A. E. S. C. 20 are concerned with mechanical engineering; 17 are civil engineering projects; 15 are electrical; three are automotive; 10 are concerned with transportation; 10 with ferrous metals; 11 with chemical; five with non-ferrous metals; four with mining; two with textiles; one with shipbuilding, and eight projects are of general interest.

Twenty-four standards or safety codes have been approved and 36 are up for approval. The remaining 4 projects represent codes and standards which are either in the process of formulation, or which are now being considered by committees of representatives, designated by the various bodies, industrial technical and governmental, interested in each particular subject. In this way, more than 200 such bodies are officially participating in the work of the A. E. S. C. through their accredited representatives.

A regular interchange of information as to the status of work under way is maintained by the American Engineering Standards Committee with the national standardizing bodies of Austria, Belgium, Canada, Czecho-Slovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden and Switzerland. This information is issued in the form of quarterly reports and includes a statement of the status of each project on which work is actively under way.

POWER EXPOSITION TO BE CONDUCTED WITH CO-OPERATION OF ENGINEERS AND OPERATING MEN

The National Exposition of Power and Mechanical Engineering to be held at the Grand Central Palace in New York from Thursday, December 7 to December 13, closing, however, on the intervening Sunday, is being planned in co-operation with the national societies interested in the economy of fuel and in the production and use of power generated therefrom.

The opening of the exposition in the Grand Central Palace will take place on the closing day of the annual meeting of the American Society of Mechanical Engineers, and time has been set aside in the A. S. M. E. program so that members desiring may attend the opening exercises. Furthermore, the programs of the 20 sessions to be held at the A. S. M. E. meetings have been so arranged that all members attending the meeting may reap the advantage of the technical discussions, and with the smallest possible expenditure of time, enjoy the novel and varied exhibits at the exposition. A few of the subjects to be discussed at the A. S. M. E. meeting are:

Commercial Economy of High Pressures and High Superheats.
Feedwater Heating for High Thermal Efficiency.
Development and Use of Stokers.
Transmission of Superheated Steam.
Ash Removal—A Symposium of Modern Handling Methods.
Gears.
Power Required for Removing Metal.
Safety Valves.
Torsion of Crankshafts.
Pulsating Flow in Flow Meters.
Dry Vacuum Pump Tests.
Design of Flywheels.
Tests on Orifice Coefficients.
A Modern Works for the Production of Monel.
Metal Steam Table Research.

In addition, the A. S. M. E. Professional Divisions on Aeronautics, Ordnance, and Forests Products will hold sessions of general interest to the engineering profession.

The American Society of Refrigerating Engineers is to hold its meeting at the Hotel Astor for three days commencing December 5, and its members, as well as the members of the A. S. M. E. will be admitted to the exposition upon the presentation of their membership cards.

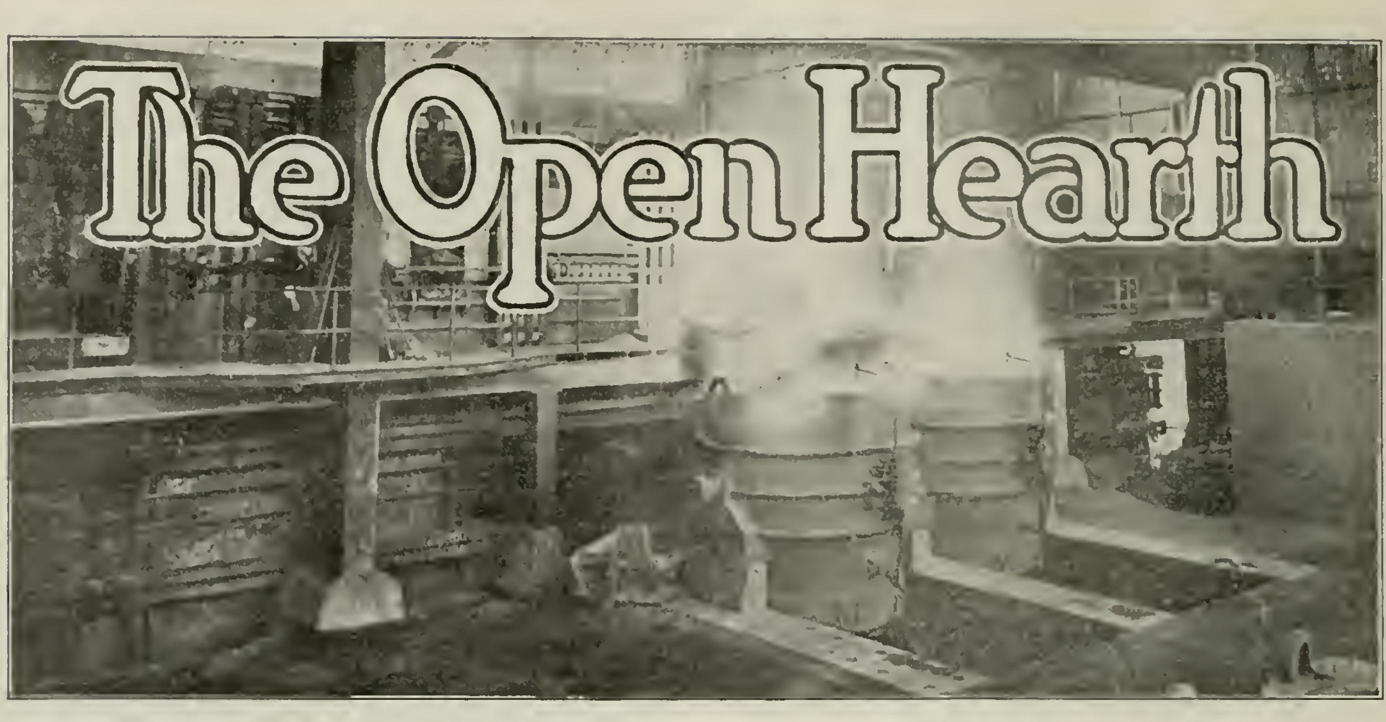
The opportunity this exposition offers for the power house operating man will also be grasped. The National Association of Stationary Engineers is perfecting plans for the various chapters to visit the exposition in a body. In addition, the New York Building Superintendents' Association, 600 strong, will attend in a body and they will be received by the officers of the N. A. S. E.

The list of exhibitors already assures the fact that the Grand Central Palace, with its remarkable facilities, will house the greatest exhibition of power plant equipment ever contemplated.

The exposition is fortunate in having an Advisory Committee that understands the importance of a greater popular appreciation of the engineering problems involved in the production and use of power. The committee is made up of Irving E. Moultrop, of the Edison Electric Illuminating Company of Boston, Chairman; Dexter S. Kimball, President of the American Society of Mechanical Engineers; Alexander G. Christie, Chairman Power Division A. S. M. E.; Fred Felderman, National President National Association of Stationary Engineers; Milan R. Bump, President National Electric Light Association; N. A. Carle, Vice-President Public Service Production Company of New Jersey; E. B. Katte, Chief Engineer Electric Traction N. Y. C. R. R. Company; Fred R. Low, Editor "Power"; David Moffat Myers, Consulting Engineer; Calvin W. Rice, Secretary The American Society of Mechanical Engineers; and the managers, Charles F. Roth and Fred W. Payne, with offices in Grand Central Palace.

STUDY OF ELECTRIC FURNACE REFRACTORIES

As it is hoped to develop refractories for electric furnaces ,it is desirable to have a method and apparatus for measuring their conductivity at advanced temperatures, states the Federal Bureau of Mines. Moreover, data in regard to the conductivity of existing refractories at temperatures above 1,400 deg. C. are meager. It is proposed by the bureau to study the leakage factor through refractories. The method of attack has been worked out and the furnace designed, the material for which is arriving at the bureau's ceramic experiment station at Columbus, Ohio.



The Open Hearth

Samuel Wesley Stratton, organizer and for 21 years director of the Bureau of Standards, Washington, has resigned to become president of the Massachusetts Institute of Technology, January 1, 1923. He succeeds Dr. Ernest Fox Nichols, who never served as president, owing to illness, but who was elected to succeed the late Richard C. McLaurin.

* *

Julius Kahn, president of the Truscon Steel Company, Youngstown, Ohio, has returned from a three months' trip to Europe and is planning soon to leave to visit the companys' plant near Tokio, Japan.

* *

Walter S. McKee has resigned as vice president and director of the American Manganese Steel Company and will develop the business of the Inland Engineering Company of Chicago, of which he is president.

* *

J. B. Clark, Jr., has recently become associated with the Pennsylvania Crusher Company as sales engineer, and will make his headquarters at the company's New York office, Hudson Terminal, 50 Church Street. For a number of years Mr. Clark has been associated with the Koppers Company of Pittsburgh in the erection of by-product coke plants, including the Seaboard Plant at Jersey City. Mr. Clark will give particular attention to engineering co-operation in connection with the installation of the company's coal preparation machinery.

* *

John Aurelius, who retired recently as superintendent of the Farrell, Pa., plant of the American Steel & Wire Company, has become connected in an operating capacity with the Otis Steel Company, Cleveland.

* *

F. E. Clarke, electric furnace expert and secretary of the open hearth committee of the United States Steel Corporation for the past seven years, has resigned to become connected with the Sizer Steel Corporation, Buffalo, as general superintendent.

* *

David L. Eynon, president of the Pittsburgh Rolls Corporation, Pittsburgh, sailed on October 10 for a two months' European tour, during which he will visit the leading steel plants of England, France and Belgium.

* *

J. L. Mueller, formerly with the American Chain Company, York, Pa., has recently resigned to become vice president and secretary in charge of production with the International Chain & Mfg. Company, that city.

* *

D. I. Miller has been appointed manager of the B. Clow & Sons Company Coshocton, Ohio, plant. Mr. Miller was manager of the Grand River, Ky., plant of that company for several years. Mr. F. W. Schwab, who has been manager of both the Coshocton and Newcomerstown, Ohio, plants, will devote his entire time to the latter plant.

* *

George D. Cameron has tendered his resignation, effective January 1, as manager of the coal department of Pickands, Mather & Company, Cleveland, which he has held for a number of years.

* *

Jay L. Hench was recently appointed manager of sales, Hillside Fluor Spar Mines, Chicago, and is also to be vice president and member of the board of directors. Mr. Hench was formerly district sales manager of the Lackawanna Steel Company at Chicago.

* *

P. L. Coyle, formerly bar mill superintendent, Jones & Laughlin Steel Company, Pittsburgh, and later works manager, Electric Alloy Steel Company, Charleroi, Pa., has been appointed superintendent of bar mills, Witherow Steel Company, Neville Island, Pittsburgh.

* *

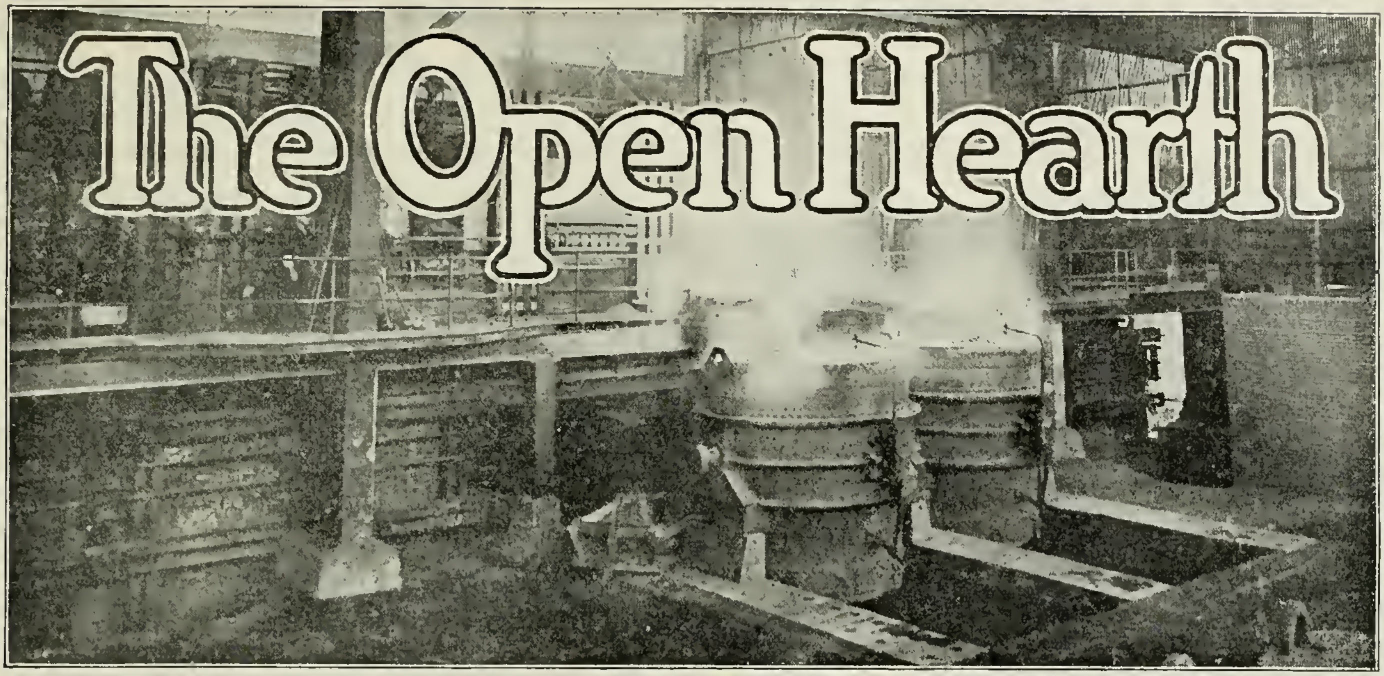
W. K. Strickland, recently with the General Motors research laboratory, has become affiliated with the Cadillac Motor Car Company, as assistant chief engineer.

* *

James P. Davis, who has been chief of the shipping and order department, National Works, National Tube Company, McKeesport, Pa., has been transferred to the general order department of the company, Pittsburgh, as assistant to J. A. Caughey, chief of that department. Mr. Davis's successor at McKeesport is C. H. Starr.

* *

James A. Buell, formerly assistant general manager of the United Alloy Steel Corporation, Canton, Ohio, has resigned to become general superintendent of the Donner Steel Company, Buffalo, N. Y.



The Open Hearth

D. Glynn Evans, metallurgist of the Llanelly Steel Company, Llanelly, Wales, manufacturers of sheet and tin bars, is visiting various iron and steel works in this country.

√ √

Sherman A. Harding, who has been Pittsburgh district sales manager for the past three years for the Betts Machine Company, Rochester, N. Y., has been appointed manager of sales in that district for the Consolidated Machine Tool Corporation of which the Betts Machine Company became a constituent company in a merger effected a few months ago. Mr. Harding became affiliated with the Bridgeford Machine Tool Works in 1909 and was superintendent of that company when it was merged with the Betts Machine Company, following which he was made general superintendent of the latter company, holding that position for about two years before being made Pittsburgh district sales manager.

√ √

Fred Gage has been named successor to John Aurelius, formerly superintendent of the company's Farrell, Pa., works, resigned. Mr. Gage was formerly assistant superintendent of the Donora, Pa., works. Charles Patt, also of the Donora works, has assumed the duties of assistant superintendent of the Farrell works made vacant by the death of John McHugh recently.

√ √

W. H. Phillippi, vice president Lackawanna Bridge Works Corporation, a subsidiary of the Lackawanna Steel Company, and one of the properties recently taken over by the Bethlehem Steel Company, has resigned.

√ √

Homer D. Williams, president Carnegie Steel Company, has been appointed member of the Pittsburgh Board of Public Education. The appointment is for six years. Mr. Williams is also a member of the State Council of Education and a trustee of the University of Pittsburgh and the Carnegie Institute of Technology.

√ √

R. C. Kirk, who retired from the presidency of La Belle Iron Works, Steubenville, Ohio, at the formation of the Wheeling Steel Corporation, a little more than two years ago, has become affiliated with the Follansbee Brothers Company, Pittsburgh, having been elected vice president, treasurer and a director of that company. Mr. Kirk takes with him an experience of more than 25 years in the steel industry.

√ √

A. L. Lee, who has been in the engineering department at the Ambridge, Pa., works, American Bridge Company, has been appointed resident engineer, United States Steel Products Company, at Bombay and Calcutta, India. He was tendered a farewell dinner and presented a gold watch by his former associates prior to his departure to his new post. Mr. Lee served overseas during the war, reaching the rank of major in the Engineer Corps.

√ √

T. W. Harris, general foreman at the blast furnace of the St. Louis Coke & Chemical Company, Granite City, Ill., sailed from New York during the week of October 26 to become connected with the blast furnace staff of the India Iron & Steel Company at Asansol, Bengal, India. He expects to arrive in India in time for the blowing in of the first 500-ton furnace, which has been under construction in the past year.

√ √

Charles P. McCrory, general manager, American Steel Company, Ellwood City, Pa., recently resigned to become president and general manager of the Liberty Steel Wire Products Company, Johnstown, Pa. Mr. McCrory has been in the steel and wire business for over 25 years, having held responsible positions with the Oliver & Roberts Wire Company, the American Steel & Wire Company and Jones & Laughlin Steel Company. He designed and built the American Steel Company plant at Ellwood City. The Liberty Steel Wire Products Company is building a new plant in Johnstown.

√ √

John Calder, consulting engineer, Lexington, Mass., who has devoted the past three years to organizing and managing the industrial relations of Swift & Company, in its various plants in the United States and Canada, as central office in Chicago, will return to his practice in organization, management and industrial counsel on November 1. Mr. Calder has been appointed industrial adviser to Swift & Company.

√ √

Edward T. Peterson was recently appointed chief engineer of the Birdsboro Steel Foundry Machine Company, Birdsboro, Pa. Mr. Peterson was formerly with the Treadwell Engineering Company, Easton, Pa.

NEWS OF THE PLANTS

The Baltimore Steel Company, Eastern Avenue and Eden Street, Baltimore, Md., has acquired property adjoining its plant, aggregating about 20,000 square feet of ground area, and will utilize as a site for the construction of an addition to its plant for considerable increase in production. The work will consist of a number of buildings, estimated to cost approximately $350,000, with machinery. Plans will be prepared in the near future.

The Nashville Bridge Company, Nashville, Tenn., has acquired property totaling about 12 acres of land at Bessemer, Ala., and has plans in preparation for the construction of a new steel fabricating plant, estimated to cost in excess of $90,000, including equipment.

The Wilmot Fleming Iron & Steel Company, 956 Foulkrod Street, Philadelphia, Pa., recently organized under state laws, has plans under way for the initial buildings for its proposed new one and two-story plant at Cottman and G Streets, for general steel and iron production. The plant will comprise a number of units, of which the first will cost approximately $75,000. It is expected to have the initial works ready for service at an early date. Wilmot Fleming is treasurer of the company.

The Weirton Steel Company, Weirton, W. Va., will commence the immediate erection of a new plant unit, aggregating about 110,000 square feet in floor area, consisting of eight complete sheet mills, to be devoted exclusively to the production of black and galvanized sheets. A site has been selected near the present stripping mill, with available land for future expansion. The new mills, with machinery, will cost about $1,500,000. A contract for the building erection has been let to the McClintic-Marshall Company, Pittsburgh, Pa. The company will also construct an addition to its open hearth department, consisting of three new furnaces, and increasing the output of this branch of the works from 700 to 1,000 tons per day. A by-product coke plant is also planned. The new extensions will give employment to more than 500 men. D. M. Weir, vice president of the company, is in charge of operations.

The Greenville Steel & Iron Company, Greenville, Pa., has plans out for bids for the construction of its proposed new plant on property recently acquired near the city limits. The works will consist of a number of buildings including one-story open hearth plant, 150x150 ft., with capacity of about 60 tons; one-story rolling mill, 150x500 ft.; power house and other miscellaneous works buildings. Other buildings will be constructed at a later date, forming a number of individual plant units, and bringing the investment to more than $3,000,000. A 500-ton blast furnace will also be built. The local Chamber of Commerce is interested in the project. Colonel H. P. Bope is president, and H. E. McConnell, managing director and consulting metallurgical engineer.

The Titusville Iron Works, South Franklin Street, Titusville, Pa., has plans under way for the construction of a new addition to its plant, for considerable increased capacity. It will be located on South Washington Street, one-story, and estimated to cost close to $100,000, with machinery and operating equipment.

The Wickwire-Spencer Steel Corporation, Webster Street, Worcester, Mass., has awarded a building contract to the E. D. Ward Company, Foster Street, Worcester, for the rebuilding of the portion of its mill at Spencer, near Worcester, recently destroyed by fire. The new structure will be three-story, 35x100 ft., and will cost approximately $60,000.

The Lockhart Iron & Steel Company, Pittsburgh, Pa., has perfected plans for the resumption of production at the plant of the Sligo Iron & Steel Company, Connellsville, Pa., recently acquired. The plant has been entirely reconstructed and improved, with the installation of considerable new equipment. It has a rated capacity of about 22,000 tons of muck bars a year, and will give employment to about 100 puddlers. Twenty puddling furnaces, with modern equipment and electric traveling crane, will be placed in service. The output of the plant will be used at the works of the Lockhart company at McKees Rocks, Pa., here to be converted into finished products.

In connection with its proposed expansion plans, the Armstrong Steel Company, Fort Worth, Texas, has acquired property at Houston, Texas, where it proposes to construct a new steel plant, estimated to cost in excess of $750,000. The works will consist of a number of buildings, including open hearth furnaces, equipped for a production of about 60,000 tons per year

The Casey-Hedges Company, Chattanooga, Tenn., manufacturer of steel plate products, has acquired local property for the construction of a new plant. It will consist of a number of buildings, devoted to the same line of present production, estimated to cost more than $100,000, including machinery. Plans will be prepared at an early date, and the project inaugurated.

The Flint Steel Company, Flint, Mich., lately organized, has taken over the plant and business of the Perkins Structural Steel Company, on local site, which has been in operation for about 12 months past. The new company contemplates a number of improvements and will operate the works at capacity. It is formed of officials of the previous organization, headed by W. L. Perkins as president and general manager.

The Atlas Steel Corporation, Dunkirk, N. Y., has been organized under state laws, with a capital of 1,000 shares of stock, no par value, to take over and consolidate the Atlas Crucible Steel Company, with local mills, and the Electric Alloy Steel Company, with plant at Charleroi, Pa. These two plants will be maintained in operation and expansion is contemplated. A branch works will also be operated at Welland, Ont. The combined assets of the consolidated company aggregate in excess of $10,000,000. Louis J. Campbell, heretofore president of the Electric Alloy Steel Company, will be one of the heads of the combined companies.

The Nagle Steel Company, Philadelphia, Pa., recently organized with a capital of $300,000, to take over and operate the plants of the company of the same name, has taken possession of the works at Pottstown, Seyfert, and Glasgow, Pa. Immediate operations are planned by the new owners; the plate mill at Pottstown will be run under full capacity, with double working shift. The Seyfert and Glasgow works will be improved and placed in service at an early date. The properties were acquired at a recent receiver's sale by George H. Heck, 518 Commercial Trust Bldg., Philadelphia, who will be one of the officials of the new organization.

Some Pointers on By-Product Coke Oven Operations

DISTRIBUTION OF SULPHUR FORMS IN COAL

During the fiscal year recently ended the investigation of the occurrence and distribution of the forms of sulphur in coal has been continued at Urbana, Ill., by the United States Bureau of Mines, in co-operation with the Illinois Geological Survey and the University of Illinois under two general heads, (1) The distribution of the forms of sulphur in the coal bed, and (2) Sulphur forms in coal. Both are closely co-ordinated with coal washing. The steadily decreasing reserves of low sulphur coal in certain sections renders it essential to have information on the occurrence and distribution of the forms of sulphur present in coals higher in sulphur; so that intelligent efforts may be directed toward reduction of sulphur and then utilization.

The distribution of the forms of sulphur in coal beds was investigated at two mines in Southern Illinois. A similar though less intensive investigation was made at a mine operating in the Pratt seam in Alabama. Since this work was done. one mine has materially reduced the sulphur content of both raw and washed coal by developing their lower sulphur forms.

The work on the sulphur forms occurring in coal is being conducted with the object of correlating the occurrence of sulphur forms with the washability of various coals with respect to sulphur reduction. During the year all the raw coal upon which washing tests were made and the washed products have been examined for the various forms of sulphur. It has been found that the organic sulphur content of a raw coal plus its content of finely disseminated pyrite sulphur fixes a limit below which no reduction in sulphur can be secured by ordinary coal washing methods.

FUSIBILITY OF COAL ASH

Data regarding the softening temperatures of coal ash from several hundred coals from the different fields of the country are contained in Bulletin 209, "Fusibility of Ash from Coals of the United States," by W. A. Selvig, assistant analytical chemist, and A. C. Fieldner, supervising chemist, just issued by the Bureau of Mines.

Information concerning the fusibility of coal ash has become of considerable value to the consumer of coal, mainly in connection with the troublesome formation of clinker resulting from the melting of the ash constituents of the burning coal. The growing interest in such data has led the Bureau of Mines to make a general survey of the "fusing" or "softening" temperatures of the ash from coals of the United States. It is hoped that this information. when used together with the large number of coal analyses published by the bureau, will assist the consumer of coal in comparing different coals, and in selecting the coal best adapted for his purpose.

Coal ash is the incombustible residue remaining after the complete combustion of coal; it is derived from the inorganic mineral constituents of the coal. The ash-forming constituents are (1) inherent or intrinsic impurities that are present in an inanimate mixture with the coal substance, and are derived either from the original material or from external sources such as sedimentation and precipitation while the coal forming plant remains accumulated; (2) impurities, formed either during the laying down of the coal bed or subsequently, that occur in the form of partings, veins, and nodules of clay, shale, "slate," pyrite, and calcite; and (3) impurities that become intimately mixed with the coal in the process of mining, such as fragments of roof and floor.

Coal ash is composed largely of compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium and alkali compounds.

Bulletin 209 may be obtained by addressing the Bureau of Mines, Washington, D. C.

DESULPHURIZATION OF COKE BY STEAM

A study of the action of steam on coke, with regard to the reduction in sulphur content of the coke, is being made at the Pittsburgh, Pa., experiment station of the Bureau of Mines by A. R. Powell, physical organic chemist, and S. H. Thompson, research fellow of the Carnegie Institute of Technology .

COAL PREPARATION

Problems that develop in the mechanical preparation of coal in the Central and Eastern coal fields are being investigated at the Central Experiment Station of the Bureau of Mines at Urbana, Ill., in co-operation with the University of Illinois and the Illinois Geological Survey. Work on coal cleaning methods is being continued, as the problem of cleaning coal is receiving more attention in the bituminous coal mining industry. A study has been made of the methods of examining a coal as it exists in the raw state, in order to determine the practicability of improving it by coal cleaning processes. The research is practically completed, and the methods developed for carrying out tests and interpreting the results are to be prepared for publication.

HEAT DISTILLATION OF COAL

J. D. Davis, fuels chemist, and Palmer B. Place, junior analytical chemist of the Pittsburgh, Pa., experimental station of the Bureau of Mines, have developed a precise method for the determination of the heat of reaction of coals during carbonization. Typical coals have been studied for reaction heats over ranges of temperature in which primary decomposition products are formed. The investigation is now being extended over higher temperature ranges where, according to theory, reaction heats should be largely endothermic.

USE OF STEAM IN COAL GAS RETORTS

The tendency toward lower standards of quality of gas in public utilities has increased the interest of the gas industry in processes that promise to increase the yield of gas per pound of coal coked, even though attended by a decrease in quality. The introduction of steam during or at the close of the coking process has shown considerable advantage in certain types of gas making installations, notably in vertical retorts. The Bureau of Mines, through W. A. Dunkley, gas engineer, has co-operated with the American Gas Association in studying the effects of using steam in horizontal retorts, which are commonly used. It was found that the method of admitting steam had much to do with the results obtained. Little, if any, water gas was generated by decomposition of steam in the retort charge, unless the contact between the steam and the chare was intimate. Steam as usually practiced in the small as plant, where the process has been tried , has no advantage. With prevailing standards of gas quality, little advantage can be taken of the use of steam, even if properly applied, as the production of any appreciable volume of water gas considerably reduced the general quality of the total gas production. Should standards be further reduced, the process might show more marked economies.

WITH THE EQUIPMENT MANUFACTURERS

NEW OPTICAL PYROMETER

The F. & F. Optical Pyrometer, according to its makers, The Scientific Materials Company of Pittsburgh, is particularly well adapted for many cases in which other types of pyrometers fail, especially:

When contact with the object, the temperature of which is to be measured, cannot be made; for example, rails passing through rolls, and other moving bodies.

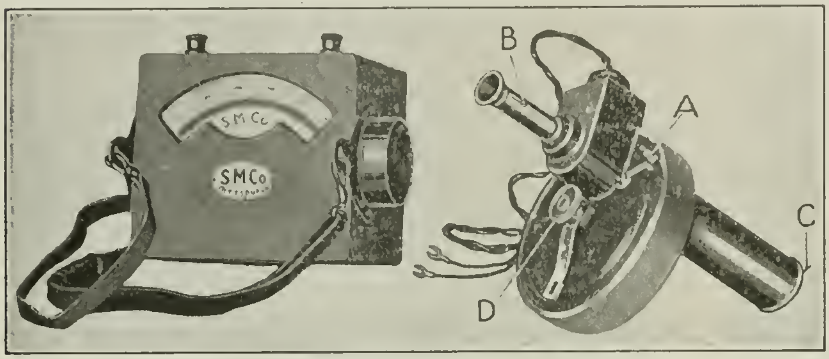


Fig. 1—F. & F. optical pyrometer. This pyrometer is but twelve inches in length and of light weight. It is convenient for using when contact with the object cannot be made.

When the pyrometer must be placed at a distance from the heated object; for example, a crucible or blast furnace.

When the temperature to be measured is above the range of thermo-couple pyrometers.

Its makers state that the operation of the instrument has been reduced to the greatest simplicity. Fig. 1 shows complete equipment. The pyrometer is small, being but 12 inches in length, and its light weight makes it convenient in handling. The metal parts are of aluminum with inserted brass and steel bearings. Both ocular and objective lenses are readily adjustable for focusing. The precision ammeter, battery and rheostat for making the normal setting are contained in a single, small, portable carrying case. The lever shown on the upper right hand side of the dial, throws in and out, the absorption glass for use with the extra scale for the high temperature range.

In making a temperature determination, the observer turns the rheostat on the battery box until the ammeter shows a certain specified reading—the "normal point." The pyrometer is then sighted on the furnace or object, the temperature of which is desired, and the knurled screwhead moving the wedge is turned until the tip of the filament disappears against the image of the source. The pointer indicates the temperature directly, no computing or reading of charts being required.

The calibration of the F. & F. pyrometer can be checked by the operator in practice, by sighting upon any known temperature. This is possible because the calibration curve of the wedge has been predetermined and always remains the same. Therefore, the correct temperature at which the lamp filament should be held is checked by sighting on a known temperature and adjusting the rheostat until the lamp filament disappears against the illuminated background.

The intensity at which the lamp burns is always kept constant. Its life is quite long as it burns at less than half of its rated capacity. This also increases the life of dry cells, as there is very small amount of current required to keep the lamp at its standard temperature.

ARMOR FRAME SINGLE ROLL COAL CRUSHER

The Pennsylvania Crusher Company, Stephen-Girard Bldg., Philadelphia, Pa., are placing on the market the Pennsylvania Armor Plate Single Roll Coal Crusher. They state that the substitution of the fabricated frame of steel plates in place of the more or less substantial cast iron frame which has been used in the past in their Bradford breaker and hammer crusher, warrants them in submitting this new design to those operating pulverized fuel plants.

The frame of the original single roll crusher, made at Hollidaysburg, Pa., naturally followed somewhat the line of double roll practice—the side frames being set on heavy timber foundations, without metal cross members, aside from the shafts. Later development provided heavy cast iron side frames and cross members. The direct drive of the roll shaft by means of a large flywheel pulley soon gave place to the powerful back geared drive through countershaft and smaller pulley. For heavy duty the frame was made in one massive box section casting, which later was sectionalized, particularly in the larger sizes.

The latest development, which marks a fundamental improvement in single roll design, provides a frame fabricated from slab steel plates into an unbreakable unit.

In the 18x18-in. and the 18x24-in. sizes, in which this design is now available, the steel side plates are 1-in. in thickness and are connected by nine steel cross members all heavily hot riveted into this rigid box frame.

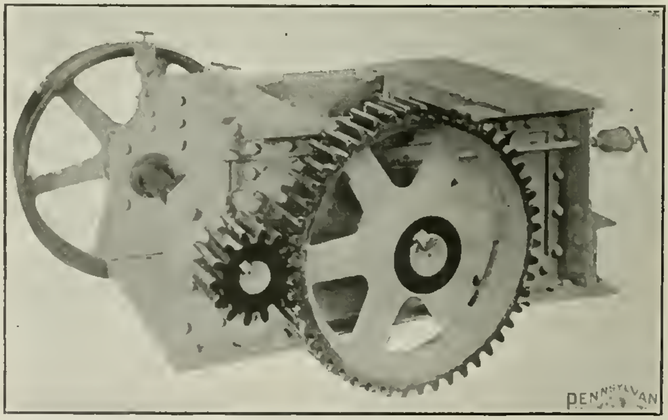


Fig. 1—Armor frame single roll coal crusher. The frame of this coal crusher is fabricated from slab steel plates in place of cast iron frames which have been used in the past.

Bronze bushed bearings are shouldered into the heavy side plates so that the bearing bolts are not subjected to shear.

The heavy flywheel pulley which drives the roll through heavy cut, back gearing, is provided with a shear pin safety device, mounting a steel bolt in hardened bushings, thereby insuring full protection of the crusher parts against the accidental introduction of tramp iron with coal.

The breaker plate is a massive casting of high grade charcoal iron deeply chilled on the crushing surface. It is hinged in the frame at the upper end and suspended at the lower end by means of powerful relief springs. The breaker plate tip, which takes most of the wear, is a reversible and renewable manganese steel casting.

The segmental roll is cast from high grade charcoal iron, deeply chilled, or from chrome steel.

Convenient provision for adequate lubrication has been made by means of large steamboat type grease cups which can be screwed down without coming into close proximity with moving parts.

The crusher proportions are unusually liberal throughout, and the design insures a continuous supply of uniformly crushed coal by affording the three safeguards—unbreakable steel frame, steel shear pin safety device and powerful relief springs—as protection against the heavy tramp iron encountered in R. O. M. bituminous coal which often has proven destructive to crushing machinery.

NEW LINE OF SMALL VERTICAL BELT DRIVEN AIR COMPRESSORS

The Ingersoll-Rand Company, 11 Broadway, New York, announces a new line of small vertical belt driven air compressors known as Type Fifteen. In addition to the plain belt drive design each size is built as a self-contained electric motor outfit, driven through pinion and internal gears or by employing the short belt drive arrangement. The compressing end and electric motor of both gear and short belt drive units are furnished mounted on a common sub-base, so that they are in no way dependent upon the foundation for correct alignment.

Several noteworthy features of construction have been incorporated, of which the "Constant-Level" Lubrication System is the most important. Others include the Constant Speed Unloader for plain belt drive machines; the Centrifugal Unloader for start and stop control machines; and the increased size of the water reservoir cooling pot.

The lubrication of small vertical compressors employing the enclosed crank case and splash system has often been a source of concern wherever oil in the air is a serious menace. The tendency of the old system has been to feed too much resulting in discharged air containing excess oil, or too little causing scored cylinders, excess loads and burned out bearings.

The "Constant-Level" system used in Type Fifteen Compressors automatically maintains a constant-level of oil, which insures the right amount being distributed to all parts.

As with the ordinary splash system, the base of the compressor forms an oil reservoir for the "Constant-Level" system. However, with this system, pet cocks determine the maximum and minimum amount of oil in the reservoir. Above this reservoir and directly underneath the connecting rod is a constant-level pan. Oil is pumped from the reservoir into this constant-level pan through a unique oil pump. Regardless of the amount of oil in the reservoir, so long as it is somewhere between the high and low level pet cocks, this system will function perfectly, insuring a constant-level of oil in the pan. A projecting stem on the connecting rod dips into this pan and distributes just a sufficient quantity of oil for proper lubrication.

The Constant Speed Unloader controls the unloading of the compressor by automatically opening the inlet valve when the receiver pressure rises above that at which the unloader is set to operate. When the receiver pressure has fallen a predetermined amount, the unloader automatically releases the inlet valve and allows the compressor to return to work and thus build up the receiver pressure again.

The Centrifugal Unloader allows the compressor to start under "no load" such as is essential when automatic start and stop control is used, and permits the electric driving motor to come up to full speed before the load is thrown on automatically. This unloader accomplishes its purpose by holding the inlet valve open until the motor has reached full speed.

The smallest size is built with either ribbed cylinder for air cooling, where the service is intermittent, or a water jacketed cylinder of the reservoir type for contant service. All other sizes are only built with the water jacket of the reservoir type. The size of these reservoir pots is very generous, and one filling will be found sufficient for long periods of operation.

A NEW COMBINATION CRANE AND SHOVEL

One of the most modern combined utility machines for the contractor, supply yard, railroad or industrial plant is the improved crawling tread crane-shovel manufactured by the Orton & Steinbrenner Company of Chicago, Ill., and Huntington, Ind.

This company was one of the first to apply the continuous-tread principle to the propulsion of locomotive cranes. Being pioneers in the field they have utilized the experience gained through successive developments and improvements to the end that the present machine is the embodiment of all the better principles of design and construction. Two sizes of machines are manufactured—the ¾-yd. and the 1-yd. capacity.

The machine is more than a crane—more than a shovel. The design is such that in a minimum amount of time simply by removing the crane boom and substituting the shovel boom and dipper, the crane may be readily converted from a clam shell rig to a steam shovel. Even this is unnecessary to convert it into a skimmer for tearing up pavement. A separate boom with skimmer scoop can be connected to crane independent of the main crane boom and the hoist line simply reeved over the scoop.

The radius of the boom instead of being fixed at a certain degree, may be varied to suit the conditions of the job. This feature enables it to dig several feet below the normal operating level and also increases the lift.

Motive power is supplied by only two engines thus simplifying operations. The hoisting, swinging and travelling operations are performed with double clutches by the main non-reversing engines, while the crowding motion of the dipper is actuated by a separate reversing engine placed midway along the boom.

The rotating base turns on a live ring of rollers on a large diameter rail circle, thus evenly distributing the load and requiring very little power to swing.

The car body is built up of structural steel shapes and plates amply riveted and thoroughly reinforced.

The housing is of sheet steel with ample sash and doors and arranged for removal when required. The operator has a clear and unobstructed view of the dipper at all times.

The crawling tread is of the flexible type, adjusting itself automatically to the contour of the ground. The tread links are so designed that in passing around sprocket all foreign materials adhering to them are thrown off and prevented from entering the spaces between.

All movable parts are bronze bushed and lubricated with Alemite pressure system and sheaves and bearings are bronze bushed.

A feature of the machine is the accessibility of its parts, especially those bearing the brunt of the wear, consequently repairs when needed, can be installed in the field with a minimum amount of lost time.

TRADE PUBLICATIONS

Pyrometers — The Bristol Company, Waterbury, Conn., is distributing a new 68-page catalog devoted to Bristol Pyrometers. This catalog is profusely illustrated and contains very valuable condensed information on this subject.

Automatic Temperature Control and Signaling Instruments — The Brown Instrument Company is circulating their new catalog No. 85, on the automatic control of temperatures through Brown indicating and recording instruments.

Ferro Alloys and Metals — The Electro Metallurgical Sales Corporation, 30 West 42nd Street, New York, is distributing a beautifully printed catalog describing ferro alloys and metals manufactured by the Electro Metallurgical Company, which has works at Niagara Falls, N. Y.; Glen Ferris, W. Va., and Holcomb Rock, Va. It describes briefly the most important "Electromelt Brand" products and their uses in the field of ferrous and nonferrous metallurgy together with some historical statements which may prove of interest to those who have not closely followed the subject.

Liquid Fuel Burning for Generation of Steam—F. J. Ryan Company, Philadelphia, Pa., is circulating a bulletin on the burning of oil in connection with the generation of steam in which they take up at some length steam atomization burners, jet burners, steam mechanical burners and low pressure air burners, discussing the duty of the burner and the cost of operating.

Link Belt Catalog — The Link Belt Company, Chicago, Ill., announce the completion of a new general catalog which embraces their entire line. This catalog not only includes the complete Link Belt line but also the products of the H. H. Caldwell & Son Company. A brief summary of the contents covered follows: Link Belt chains, power transmission machinery, helicord and screw conveyors, conveyor equipment, boiler plant and coal tipple equipment, coal storage equipment, skips, etc., portable loaders, conveyors, locomotive and trolley type cranes, grab buckets, electric hoists and other special equipment.

Electric Furnaces — The Electric Company, Salem, Ohio, has recently published a six-page circular illustrating some of their many types of Bailey electric enameling, annealing and heat treating furnaces which they have installed in the last few years. They are also distributing a circular on melting furnaces which are used for the melting of nonferrous metals.

Blowers — Syracuse Industrial Gas Company, 208 S. Geddes Street, Syracuse, N. Y., is distributing a bulletin describing their uniform Multi-Stage Fan Type Blower, which is built in small capacities.

Air Conditioning — Reprint No. 729 from the Public Health Reprints of the Treasury Department of the U. S. Public Health Service is a paper prepared by C. E. A. Winslow, Professor of Public Health, Yale School of Medicine, on "Various Systems of Air Conditioning in a Munition Factory."

Coxe Stoker — The Combustion Engineering Corporation, Combustion Engineering Building, N. Y., have issued within the past month a bulletin covering the performance of this stoker on Western and Midwestern bituminous coal. A number of test charts each accompanied by corresponding curves are included. These tests show very remarkable results, and because they are complete in every respect will be of considerable interest to the engineering world. These stokers have proved successful in burning bituminous coal although three years ago it was thought to be impossible on draft, traveling grate stokers.

Elements of Industrial Heating — The W. S. Rockwell Company, Furnace Engineers, 50 Church Street, N. Y., is distributing a booklet prepared in an effort to give a proper view of the principals governing heat treatment of metallurgical, chemical and ceramic products, and the selection and use of equipment, fuel or electricity as a means to that end. They state that the matter is entirely technical and has been reviewed by teachers and engineers who have insured its accuracy and freedom from bias.

Steel Structure — McClintic Marshall Company, Pittsburgh, Pa., is distributing a book illustrating a number of buildings which they have erected in the past. This booklet is very beautifully bound and printed.

Furnace Chart Calculator — The Pittsburgh Electric Furnace Corporation, Pittsburgh, Pa., is distributing 'lectro calculator, which is a form of circular slide for calculating the additions of various alloys and metal mixtures to alloy in given percentage of alloy, and alloy in ordinary percentage of loss in the absorption of alloy. It is intended for the use of furnace superintendents and melters and the metallurgical profession in general; and will prove valuable in making calculations for the purposes intended.

TRADE NOTES

The Conveyors Corporation of America, 326 West Madison Street, Chicago, Ill., has appointed the George W. Fife Engineering Company, 1403 Merchants Bank Building, Indianapolis, Indiana, its representative for the sale of American Trolley Carrier in the State of Indiana. The American Trolley Carrier is equipment for handling coal from railroad cars to bunkers, silos or open storage pile. It consists of an overhead monorail, with a trolley from which a one-ton bottom dump bucket is suspended.

Westinghouse Krantz Works Moved to Mansfield.

Increased business necessitating increased production and more adequate facilities has resulted in the transfer of the Krantz works of the Westinghouse Electric & Manufacturing Company to Mansfield, O. The transfer of the Krantz works to Mansfield offers better facilities for increased production and gives the works a location in the central part of the country with easy access to a large number of railroads and to both the Middle West and Eastern offices of the Westinghouse Company.

Westinghouse Opens Sales and Service Building In Minneapolis.

In order to adequately serve the great territory known as the Twin-City area, the Westinghouse Electric & Manufacturing Company has leased a six-story building in the Minneapolis industrial district which will serve as a combined sales, service and warehouse center. The structure, which was built especially for and is leased by the Westinghouse Company for a period of 20 years, is one of a group of buildings included in the plan of the Northwestern Terminal Company of Minneapolis to provide an efficient and economical distributing service for the products of eastern manufacturers.

In order to promote the demand for corrugated metal roofing and siding protected with asbestos and asphalt, the Johns-Manvills, Inc., Pittsburgh, have been appointed joint selling agents by the H. H. Robertson Company, Pittsburgh. In the future all asbestos protected metal (more recently called Robertson Process Metal) roofing, siding, accessories and ventilators will be manufactured and shipped from the plant of H. H. Robertson Company at Ambridge, near Pittsburgh, Pa. Hereafter in the manufacture of Asbestos Protected Metal products by H. H. Robertson Company, the Johns-Manville asbestos saturated felts will be used.

COMING MEETINGS

December 7-13 — National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace with the exception of the intervening Sunday.

Oxwelding steel hatch combings

Right Angling Angle Irons

A neat, economical and permanent joint right on the spot and in a few minutes' time—that's an every-day example of oxwelding.

Wherever joining or cutting metals will save time and money—the oxwelding and cutting blow-pipes are essential.

Oxwelding is a production factor in hundreds of plants and wherever it has been applied to manufacturing the result is invariably a better product at reduced cost and in less time.

And in the upkeep of machinery, oxwelding is indispensable—remaking worn and broken parts at nominal expense and with scarcely any lost motion.

Oxweld Service Engineers, stationed in more than fifty important cities, await your pleasure to demonstrate the application of the process to your own problems of production and reclamation.

Write for an illustrated book "Oxweld Can Do It!"

What Oxweld has done for others—Oxweld can do for you.

An illustrated book "Oxweld Can Do It" tells what oxwelding is doing—write for it

OXWELD ACETYLENE COMPANY *· Newark, N. J. · Chicago · San Francisco*

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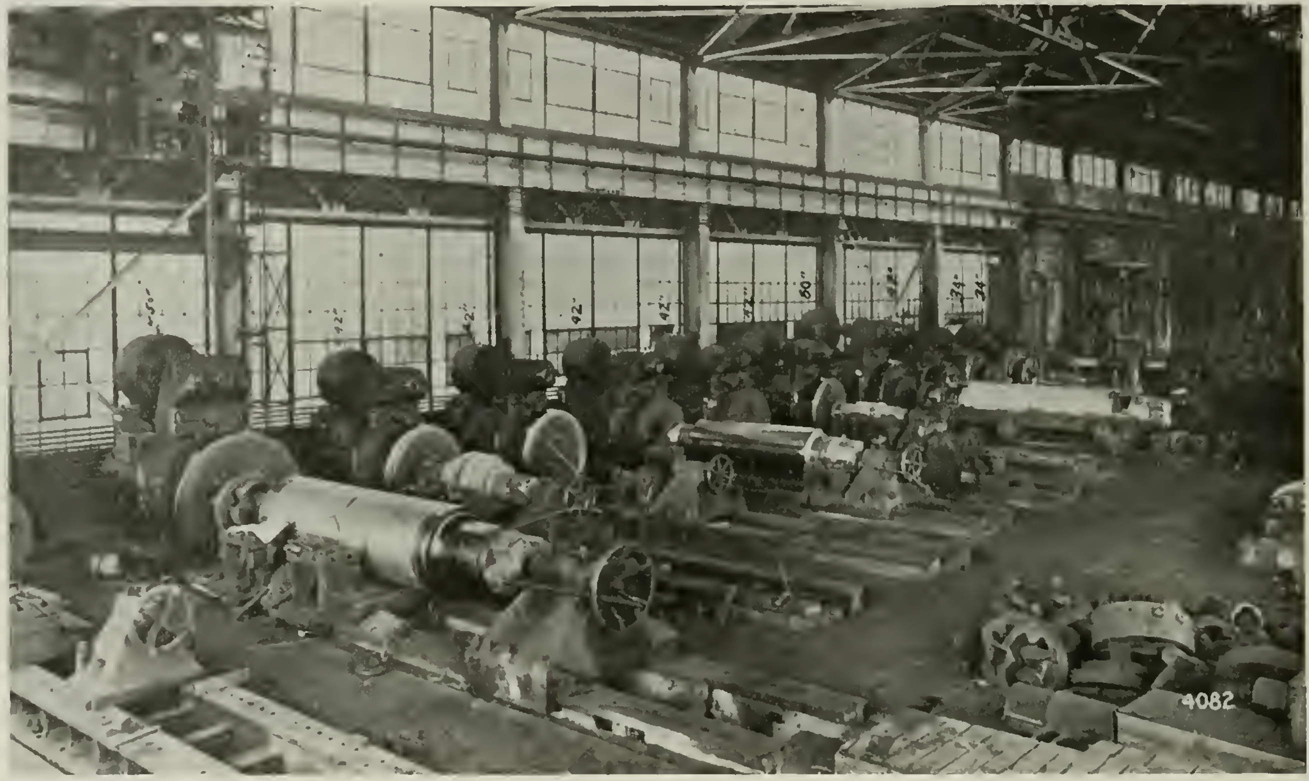
QUALITY "UNITED" SERVICE

COMPLETE
ROLLING MILL EQUIPMENT



Group of 10 "United" heavy duty roll lathes in our American plant at Canton, Ohio, which is equipped with 26 roll lathes. This is one of three large modern roll turning shops operated in connection with our roll department, enabling us to give our customers the best possible roll turning service.

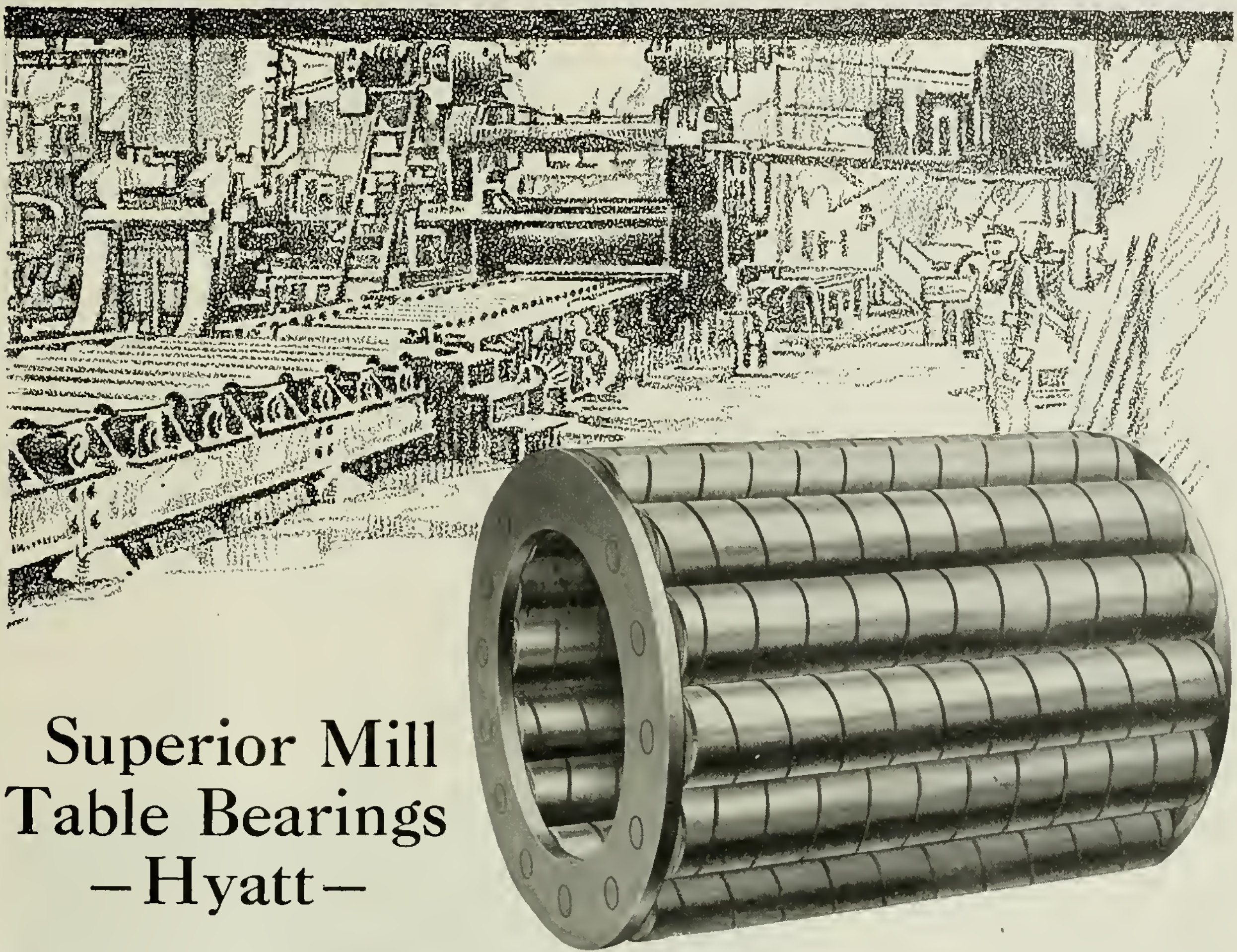
We were originators of the heavy duty type of roll lathe, and have steadily developed this type of lathe to meet the exacting and special requirements of the art of roll turning. In this development, parts were strengthened, improvements made and designs simplified as experience and operating conditions brought out these points.

Heavy Duty Roll Lathes are built in the following sizes:
18" - 26" - 34" - 42" - 50"

United Engineering & Foundry Co.

Pittsburgh, Pa.

THE WORLD'S GREATEST MANUFACTURERS OF COMPLETE ROLLING MILL MACHINERY FOR IRON, STEEL AND TUBE WORKS



Superior Mill Table Bearings –Hyatt–

To properly stand up under the severe conditions of reversing blooming mill table service, the bearings you select must have durability built into them.

The improved type of Hyatt roller bearing developed principally for blooming mill tables has this necessary inbuilt durability.

When you plan the rebuilding of your present mill tables remember that by using the correct size of improved Hyatt mill table bearing to meet the conditions of your mill, you can avoid the costly delays experienced when ordinary bearings are used.

To eliminate delays due to bearing replacements, to reduce maintenance, and to produce steel at minimum cost per ton, incorporate Hyatt mill table bearings in your design.

Get in touch with our engineers in Chicago, Philadelphia or Pittsburgh, they can be of practical assistance in properly applying these modern bearings to your equipment.

Hyatt Roller Bearing Co. Industrial Bearings Division **New York, N. Y.**

Motor Bearings Division, Detroit
Tractor Bearings Division, Chicago

USE HYATT BEARING HANGERS SAVE POWER IN YOUR MACHINE SHOP BULLETIN 127

Pacific Coast Division
San Francisco

The Automatic Heavy Duty Gas Producer

—Has the Following Features—

AUTOMATIC FEEDING OF THE COAL

AUTOMATIC ASH DISCHARGE

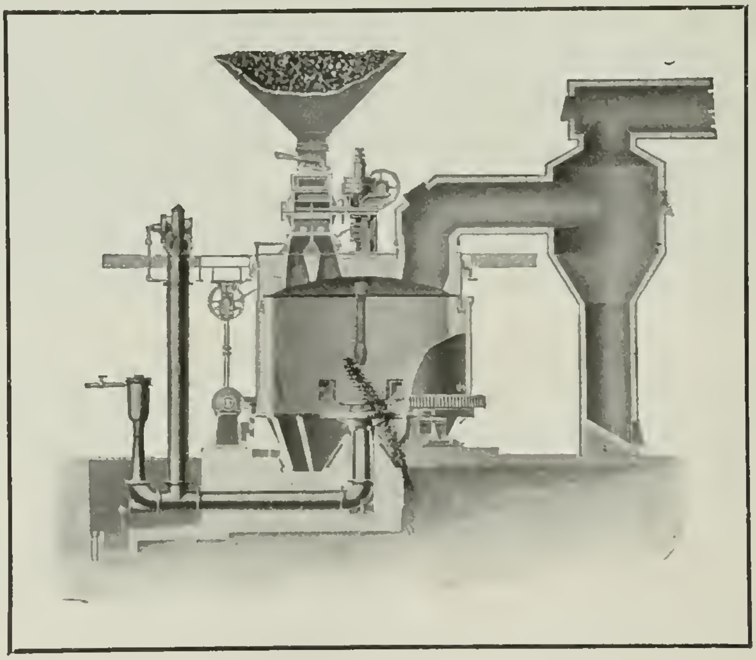
AUTOMATIC AGITATION OF THE FUEL BED

ARCHED FIRE BRICK TOP

TURBO FAN BLOWER EQUIPMENT

WORM DRIVE OF SHELL AND BARS

Gasifies 50 tons
of coal in
24 hours



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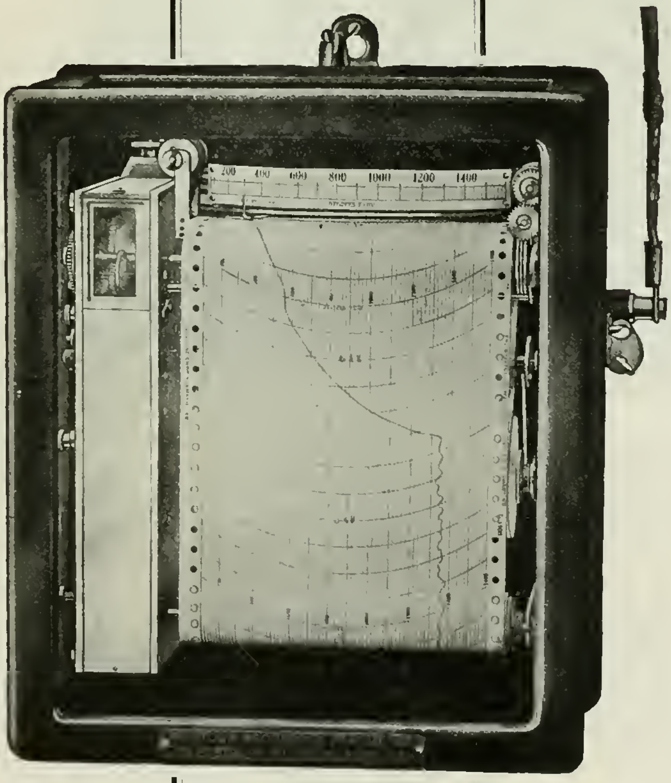
REG. U. S. PAT. OFFICE.



Forty-five Days at a Stretch

Long operations may be recorded complete on this Bristol's Strip Type Recording Pyrometer. Several long furnace heats may be recorded in sequence with a minimum amount of attention. Maximum accuracy and dependability bring to this convenience the other characteristics which must recommend Bristol Equipment most highly to your own attentions.

And in speaking of accuracy the Automatic Internal Cold End Compensator, are exclusive feature with Bristol's Pyrometer, should not be overlooked. This is a simple device located within the instrument itself (also where the cold end is) which automatically compensates for any variations in the temperature of the cold end of the thermo-couple.

The whole story of Bristol's utility cannot be told in a few words, but it may not take many to show you where the proper installations can save you real money.

Let us send you our new Pyrometer Catalog AD-1401.

The Bristol Company

Waterbury, Conn.

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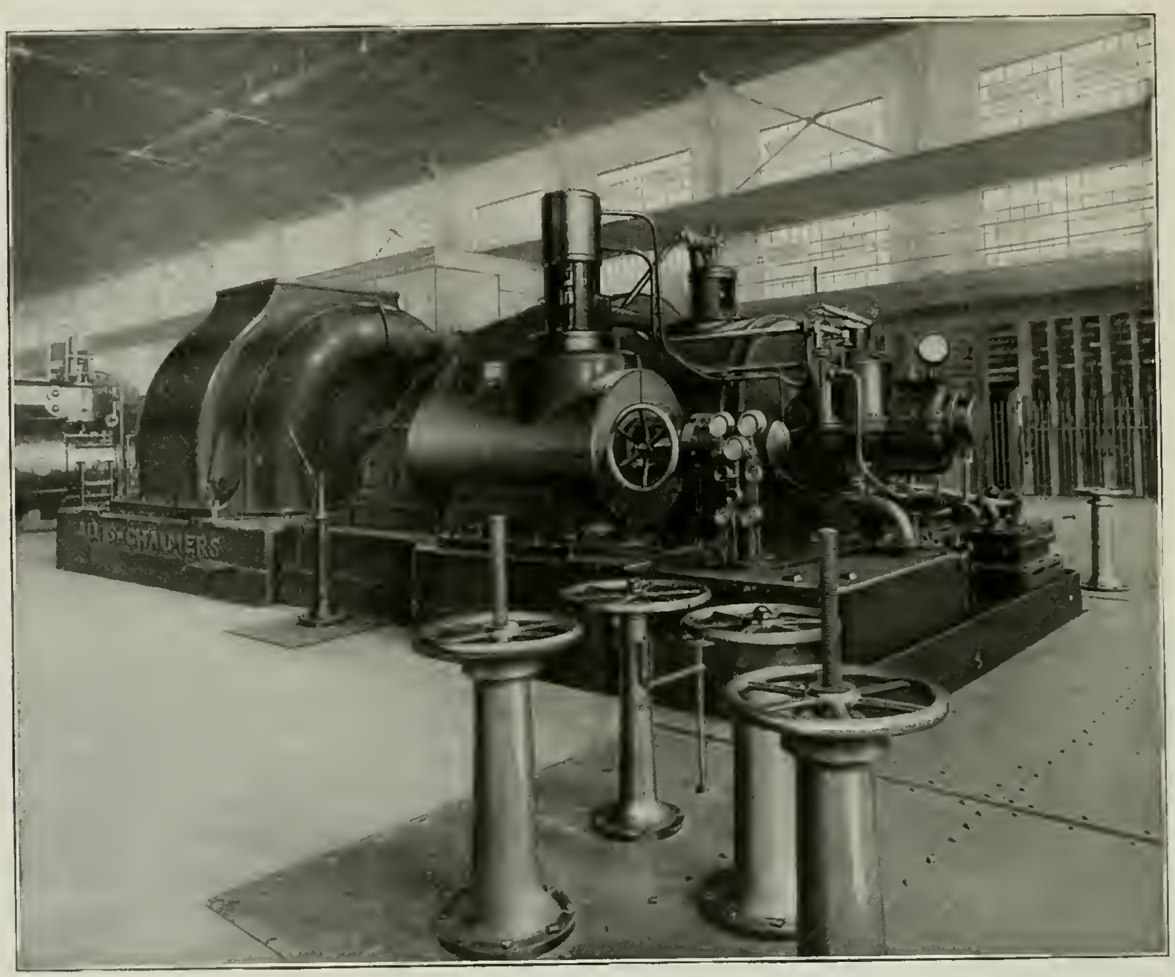
STEEL MILL POWER



The above cut shows one of two 7500 k. w. 1500 R.P.M. Steam Turbo-Generators installed in one of the most modern Steel Mills in the United States.

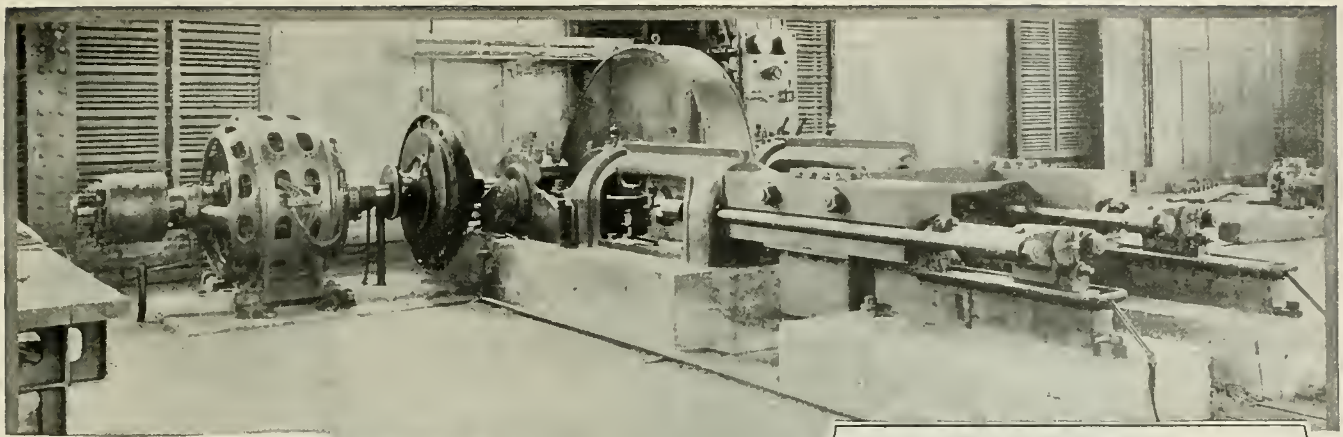
Allis-Chalmers Steam Turbines are installed in a number of mills prominent in this country's steel industry and their record proves their exceptional suitability for this severe service.

Allis-Chalmers Products

Electrical Machinery
Steam Turbines
Steam Engines
Condensers
Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
Gas Engines
Oil Engines
Mining Machinery
Metallurgical Machinery
Crushing and Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery
Perforated Metal
Timber Treating and Preserving Machinery

ALLIS-CHALMERS

MILWAUKEE, WIS. U. S. A.



C-H 44-inch Magnetic Clutch between the 350 HP A. C. Synchronous Motor and accumulatar pump.

Eliminating Unnecessary Pump Wear and Lowering Power Bills

Many new ways of effecting savings through the application of the easily-controlled, rugged C-H Magnetic Clutches, are being discovered by engineers and industrial heads.

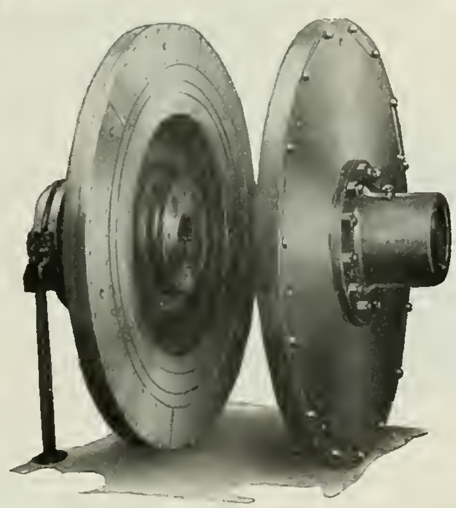
The application shown above is a case in point:—Instead of the usual method of operating this accumulator pump continuously with squirrel cage or slip ring motor—a "power-factor-increasing" synchronous motor was installed, driving the pump through a C-H Clutch.

Instead of loading and unloading by means of valves, the pump now runs only when actual work is to be done, thus saving unnecessary wear.

When the synchronous motor is up to speed, the Magnetic Clutch is engaged, after which it may be disengaged and re-engaged by merely touching a button or manipulating a small switch.

While idling as a condenser on the line, the motor improves the power factor and lowers power costs.

In your plant you can take advantage of these same characteristics—probably make unnecessary additional transformer or copper capacity, or decrease your demand charge. Let us tell you how.



Exploded view of C-H Magnetic Clutch—no toggles, links, levers. That's why they stand the gaff.

The C-H Magnetic Clutch consists of but two parts, one of which carries the magnetic coil. There are no toggles, links, etc.

Engagement and disengagement are thus easily controlled by simply pushing a button or operating a small switch.

These clutches require but small space and operate successfully at high or low speeds. They do not grab their load, but have smooth accelerating action. The period of energizing is sufficient to cushion the force of engagement.

THE CUTLER-HAMMER MFG. CO.
Magnet and Clutch Department
Works: MILWAUKEE *and* NEW YORK
Offices and Agents in Principal Cities
Northern Electric Co., Ltd., Canada

Pub. 2030

C-H MAGNETIC CLUTCHES

WATER COOLED DOORS and FRAMES

BLAW-KNOX
Water-Cooled
Doors and Frames
Skewbacks
Ports
Damper Type Reversing Valves
Buckstays
etc.

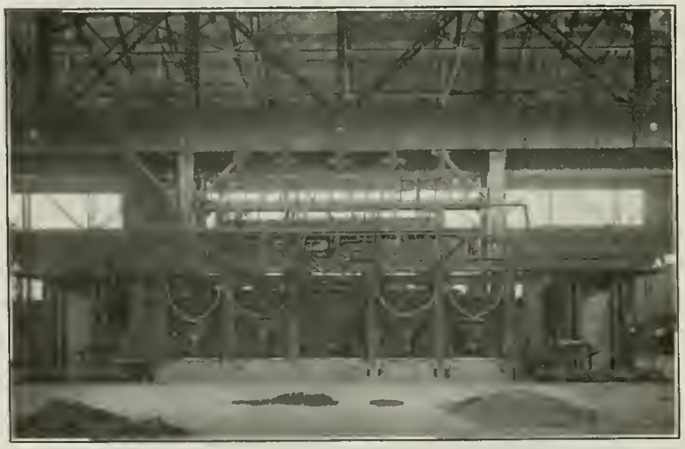
Six Times the Life of DRY Doors and Frames

represents conservatively the life of Knox Water Cooled Doors and Frames for Open Hearth Furnaces.

Aside from the actual proven dollars and cents savings of Knox Doors and Frames, the efficiency of labor is greatly increased; as they make the area immediately in front of the furnace more comfortable for the operators.

The great majority of open hearths all over the county are already Knox equipped because this apparatus has so conclusively proven its savings upon installations.

Write for further information about Knox Water Cooled Equipment for High Temperature Furnaces.

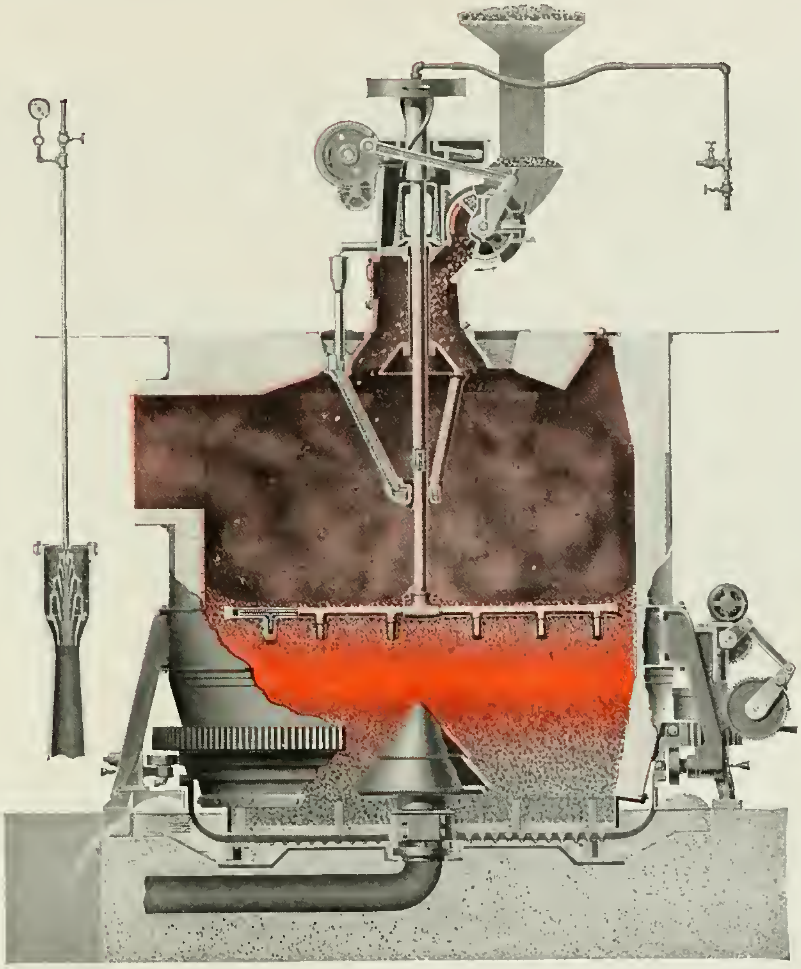


A Typical
Blaw-Knox Equipped Furnace

BLAW-KNOX COMPANY
615 Farmer's Bank Bldg., Pittsburgh, Pa.
New York Chicago Baltimore Detroit
Birmingham London, Eng.

KNOX WATER COOLED EQUIPMENT

"It Really Is Continuous"



Continuous
Coal Feed,
Agitation and
Ash Removal

"We Move the
Parts That Do
the Work"

Chapman Continuous Gas Producer

For five years we've "moved the parts that do the work." Our Continuous ash removal is on this same principle.

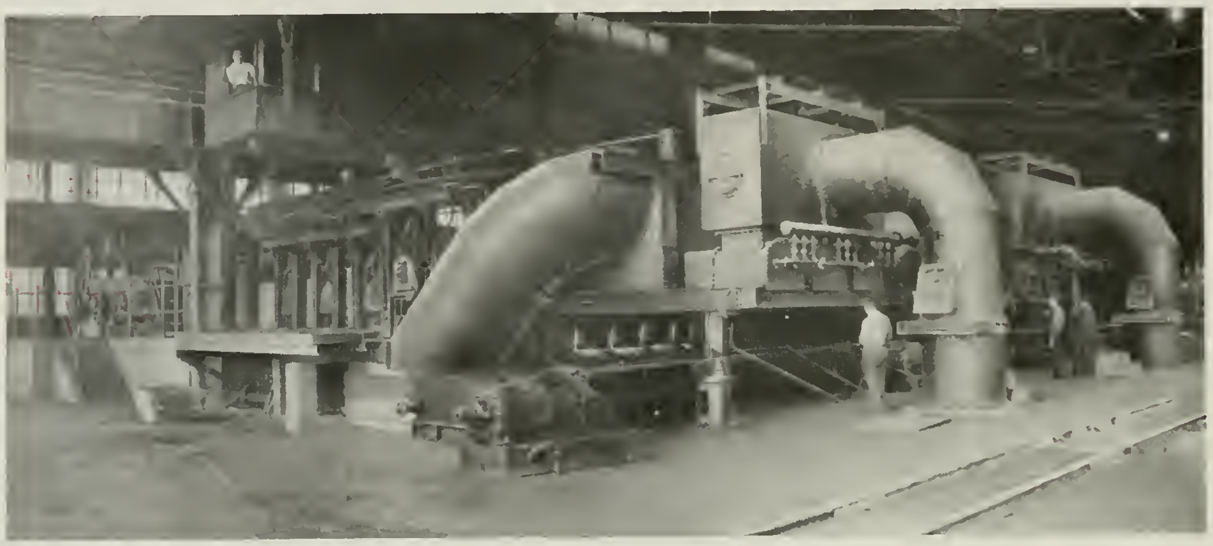
The three steps in producer gas making—coal feeding, agitation and ash removal—all progress continuously (not intermittently) in the Chapman Continuous Gas Producer. This means uniformity in the fire bed, which produces the uniformly rich gas so necessary to fuel economy.

The massive shell with its several tons of fire brick is stationary, so is the ash pan, for only those parts move that do effective work. The Agitator Bar and Ashing Arm are entirely independent and the speed of each can readily be adjusted to harmonize with the other.

A letter from you will bring complete information on Chapman Gas Machinery and Engineering Service.

The
CHAPMAN ENGINEERING CO.
Division of The
C&G COOPER CO.
MT. VERNON, OHIO
Oliver Bldg., Pittsburgh 50 Church St., New York
Since 1833 Engineers and Builders

The Chapman-Stein Refractory Tile Recuperator Furnace Is Leak Proof



Two Chapman-Stein Billet Heating Furnaces in the Youngstown Sheet & Tube Plant, Youngstown, Ohio

FORCE a Chapman-Stein Billet Heating furnace if you wish—you need have no fear of burning out the recuperators for they are made of the same material as the best fire brick. They have air capacity for 100% overload without any leakage between the air and waste heat flues because the pressure on either side is always equal.

The mill never waits for steel when the billets are coming from a Chapman-Stein Furnace. A very high temperature can be held so constant and is so uniform from side to side of the furnace that the continuous discharge of billets need never be interrupted. There are installations where the tonnage has been doubled. At the same time by reason of the efficient combustion and transfer of heat, the fuel consumption was reduced nearly 20%.

Oxidation losses are negligible, due to a positive pressure within every Chapman-Stein Furnace, which prevents air from being drawn in through the doors and peep holes.

These are some of the features which make Chapman-Stein Billet Heating Furnaces good paying investments.

The
CHAPMAN-STEIN FURNACE CO.
C&G *Division of The*
COOPER
CO.
MT. VERNON, OHIO
Oliver Bldg., Pittsburgh 50 Church St., New York
Since 1833 Engineers and Builders

CONTRACT BLANK

The Andresen Company, Inc.,
Publishers of "Blast Furnace and Steel Plant,"
Thaw Building, Pittsburgh, Pa.

Gentlemen:

We desire to be represented in your January Annual Review and Reference Issue of BLAST FURNACE AND STEEL PLANT and you may reserve on our account .... pages to appear in the following sections that we have checked:

ADVERTISING SECTIONS AS THEY WILL APPEAR IN THE 1923 JANUARY ANNUAL REVIEW AND REFERENCE ISSUE OF THE BLAST FURNACE AND STEEL PLANT

☐ **Construction and Engineering Section**
  (a) By-Product Coke Plants
  (b) Blast Furnace Plants
  (c) Structural Plants
  (d) Engineers

☐ **Rolling Mill Equipment Section**
  (a) Rolling Mills
  (b) Rolls

☐ **Transmission Section**
  (a) Drives
  (b) Belting
  (c) Bearings
  (d) Lubricants
  (e) Bearing Metals

☐ **Material Handling Section**
  (a) Cranes and Hoists
  (b) Trucks, Tractors, Industrial Cars
  (c) Locomotives
  (d) Ladle Cars, Charging Cars, etc.
  (e) Buckets

☐ **Recording Instrument Section**
  (a) Pyrometers
  (b) Testing Instruments
  (c) Recorders, etc.

☐ **Machine Tool Section**
  (a) Shears
  (b) Bar Cutters
  (c) Lathes, etc.

☐ **Miscellaneous**
  (a) Welding Equipment
  (b) Safety Apparatus
  (c) Scales, etc.

☐ **Furnace Section**
  (a) Open Hearth Furnaces
  (b) Electric Melting Furnaces
  (c) Forging and Heat Treating Furnaces

☐ **Fuel Section**
  (a) Powdered Coal Equipment
  (b) Gas Producers
  (c) Gas, Coal, Fuel Oil, etc.

☐ **Metals and Raw Materials Section**
  (a) Pig Iron
  (b) Iron Ore
  (c) Coke
  (d) Alloys

☐ **Refractories Section**
  (a) Fire Brick
  (b) Cement

☐ **Electrical Section**
  (a) Motors
  (b) Generators
  (c) General Electrical Equipment

☐ **Power Plant Section**
  (a) Boilers
  (b) Piping
  (c) Valves

☐ **Forging Equipment Section**
  (a) Hammers
  (b) Presses (Hydraulic)

As per your special offer, all advertisements appearing in the January Annual issue are to be printed on coated colored insert stock and the issue is to have a guaranteed distribution of 5,000 copies.

For the above service we agree to pay in accordance with the following schedule of rates:

One Page	$100.00	Four Pages	$300.00
Two Pages	175.00	Eight Pages	500.00

Copy instructions will be mailed to you date.......................................1922

Company ....

By ....

Address.......................................

Accepted by:
The Andresen Company, Inc.

............................President
Thaw Building, Pittsburgh, Pa.

You Should Be Represented in the January Annual Review
and Reference Issue of

The Blast Furnace and Steel Plant

which this year has many added features that promise to even increase its already well established value as a reference number.

> The editorial pages will be more interesting than ever and will surpass in practical value any contributions that we have ever been able to extend to the Iron and Steel industry. Every article written by the leading authority on the subject he presents.

This is the issue that you cannot afford to pass by without presenting the complete story on what you have to offer in the way of improved equipment.

**The January Annual Review and Reference Issue
of the**

The Blast Furnace and Steel Plant

offers advertisers an opportunity of extending a word of good cheer for a happy and prosperous New Year.

The psychological time to tell your complete sales story to the **5,000** or more operating officials of the steel industry, who will read this issue with keenest enthusiasm.

This is the issue in which everyone expects to see your equipment advertised.

DON'T MISS THIS OPPORTUNITY

Its unique arrangement of advertising pages this year makes it doubly attractive and effective from an advertising point of view and gives you opportunity of appearing in a special section together with the other manufacturers who produce like equipment.

All advertising pages this year will be printed on coated colored insert stock and arranged into sections as outlined on the reverse side of this sheet—all sections being separated with title pages so as to make each group of advertisements independent of each other.

Send in your reservation early so as to secure a preferred location.

Better yet, wire your reservation immediately at our expense.

See other side for rates, classification of advertising, etc.

THE IRONSIDES COMPANY
COLUMBUS OHIO

Ironsides Gear Shield

TRADE MARKS REGISTERED
IRON SIDES

Ironsides Wire Rope Shield

Ironsides Automobile Gear Shield

Metal Costs More Than Lubricants—It's cheaper to preserve your wire ropes and gears with Ironsides lubricants than to replace them frequently.

Ironsides Wire Rope Shield—for preservation and lubrication—widely used in Mines, Blast Furnaces, Steel Plants and Factories.

Ironsides Gear Shield—lessens noise, wear and costly replacements—used by up-to-date Rolling Mills.

Ironsides Cold Neck Shield—the best roll-neck lubricant in existence—for Rolling Mills.

Ironsides Cold Neck Shield

Service Plus Satisfaction

are incorporated into every Pittsburgh Piping installation. Pipe Bends used in place of elbows, provide for expansion and contraction, reduce friction and minimize loss of pressure.

Our machine shop, bending, forging and welding departments and our iron and steel foundries are equipped with the most modern tools and appliances.

Specify "Pittsburgh Piping" and you mention the best there is in Power Plant Piping construction.

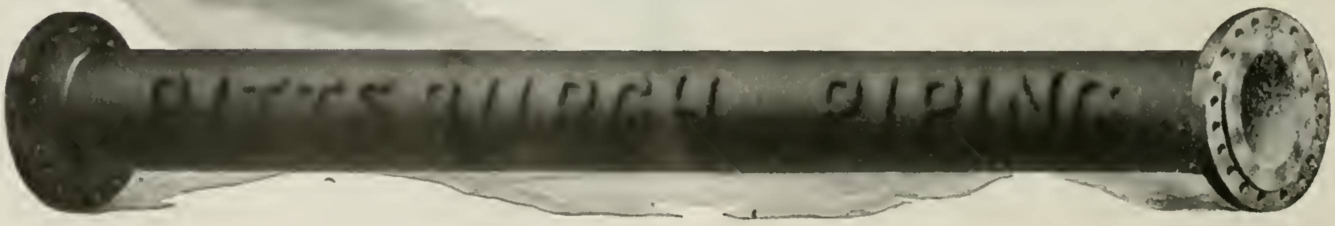
"WHEN YOU
THINK OF PIPING
THINK OF PITTSBURGH
PIPING"

PITTSBURGH PIPING & EQUIPMENT CO.

MANUFACTURERS & CONTRACTORS

PITTSBURGH, PA.

NEW YORK 220 BROADWAY	CHICAGO PEOPLES GAS BLDG.	SAN FRANCISCO MONADNOCK BLDG.
CLEVELAND AMERICAN TRUST BLDG.	INDIANAPOLIS TRACTION TERMINAL BLDG.	BIRMINGHAM AMERICAN TRUST BLDG.

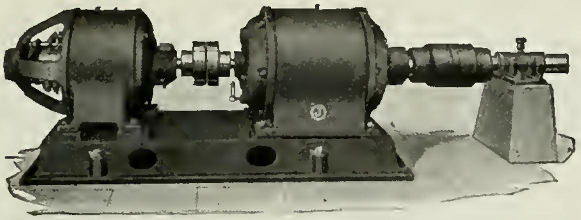


Jones

Spur Gear Speed Reducers

An enclosed spur gear drive for reducing motor speeds by direct connecting the motor shaft to the high speed shaft of the reducer through a flexible coupling. Mechanically correct; the few parts are simple, strong and efficient. All speed reduction is accomplished by ordinary gear drives — gears are all the straight external spur type of high carbon steel.

Ask for new speed reducer catalog



W. A. Jones Foundry & Machine Company

MAIN OFFICE AND WORKS:
4429 West Roosevelt Road, Chicago

BRANCH SALES AND ENGINEERING OFFICES:

26 Murray St.
New York, N. Y.

Union Arcade
Pittsburgh, P. A.

2482 University Ave.
St. Paul, Minn.

184 Main St.
Buffalo, N. Y.

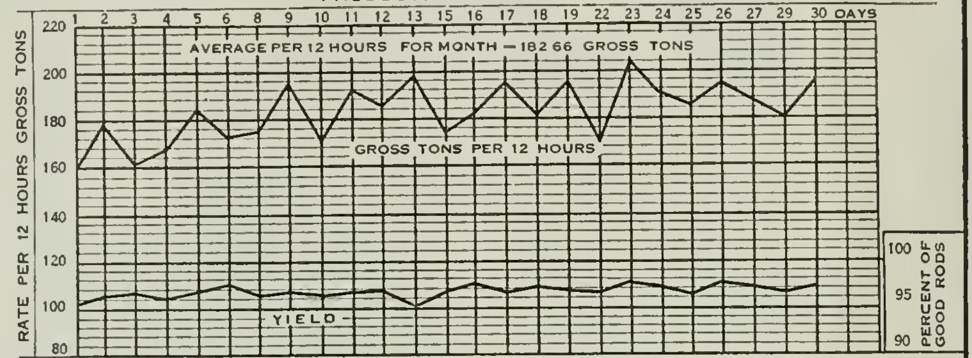
1st Wis. Nat'l Bank Bldg.
Milwaukee, Wis.

Cast-Iron Pulleys · Friction Clutches · Shaft Hangers · Boxes · Couplings
Cut Gears · Cast Gears · Sprocket Wheels · Rope Sheaves
Flywheels · Enclosed Worm Gear Drives
Spur Gear Speed Reducers

MORGAN
OF WORCESTER
CONTINUOUS DOUBLE STRAND ROD MILLS

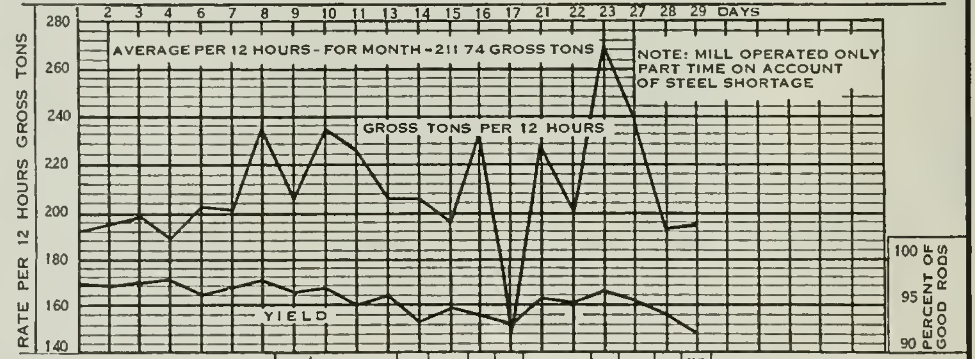
M C Co

MONTHLY RECORD APRIL 1918
PRODUCTION ON No. 5 RODS

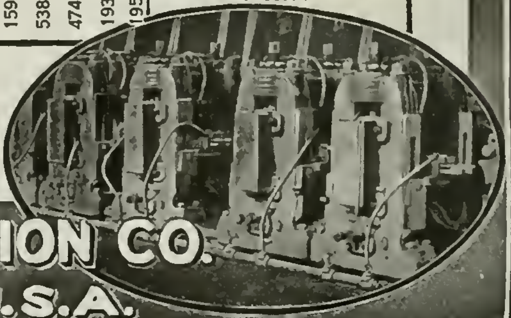


DAYS	1	2	3	4	5	6	8	9	10	11	12	13	15	16	17	18	19	22	23	24	25	26	27	29	30	
SIZE OF ROD	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
HOURS	24	24	24	24	24	10	24	24	24	24	24	6	24	24	24	24	24	24	24	24	24	24	10	24	24	554 46.17 SINGLE TURNS
GROSS TONS	325.87	354.45	327.65	334.81	369.62	144.63	349.98	389.27	341.95	383.02	372.29	99.11	346.41	360.70	385.70	363.37	391.05	337.48	407.12	379.44	374.08	387.47	156.24	361.59	390.17	TOTAL GROSS, TONS 8433.47

MONTHLY RECORD MAY 1918
PRODUCTION ON MISCELLANEOUS ROD SIZES



DAYS	1	2	3	4	6	7	8	9	10	11	13	14	15	16	17	21	22	23	27	28	29	
SIZE OF ROD	5	5	5	5	3	3	3	3 2	2	2	0	0 .312	.306 .312 00	00 .343	00 1	1	1	.393 .406	.406 .378 .363	.383 .430	.462 .468	
HOURS	24	24	24	10	24	24	24	24	24	7	24	24	24	24	12	24	9.4	24	24	12	12	422.4 35.20 SINGLE TURNS
GROSS TONS	384.81	388.38	391.05	155.35	407.12	406.22	466.93	409.80	466.05	133.03	410.68	411.58	392.83	462.48	150.88	454.43	159.81	538.36	474.08	193.74	195.53	TOTAL GROSS TONS 7453.14



Pittsburgh Office
610 Magee Bldg. Telephone Court 1381

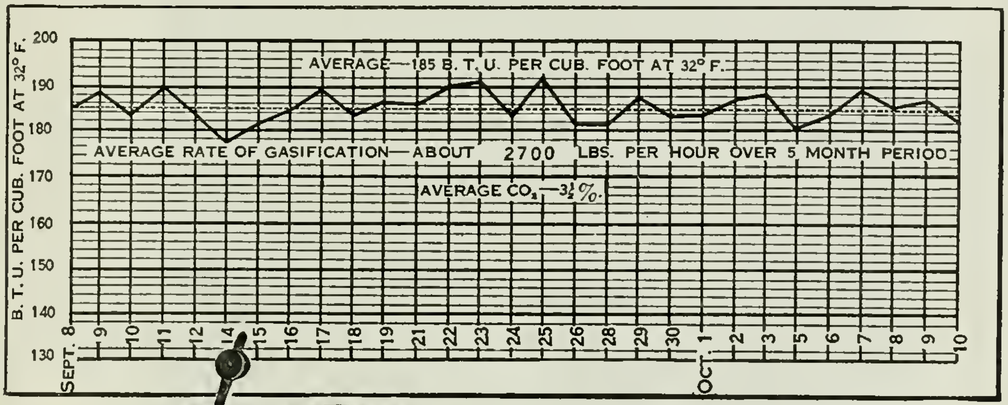
MORGAN CONSTRUCTION CO.
WORCESTER, MASS., U.S.A.

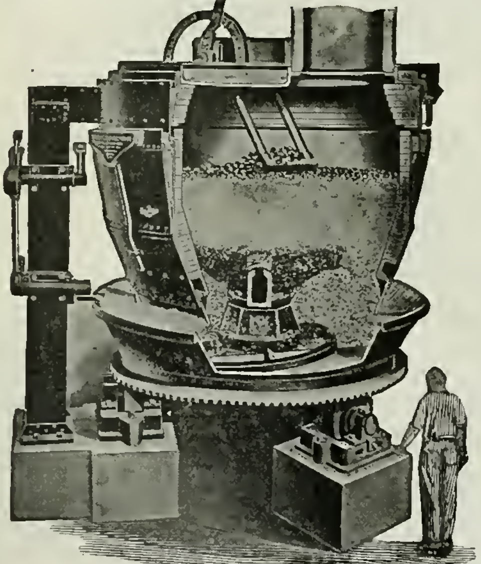
MORGAN
OF WORCESTER

PRODUCER GAS MACHINE

M C Co

Eight-hour Continuous Gas Samples from records of work's chemist at one of the well known Steel Plants in the U.S.A.





MORGAN
PRODUCER GAS
MACHINES

maintain the quality of gas continuously at a high value - - - operation is less dependent upon the human element - - -

Continuous Mechanical Feeding, Levelling and Ash Discharge

Pittsburgh Office
610 Magee Bldg. Telephone Court 1381

MORGAN CONSTRUCTION CO.
WORCESTER, MASS., U.S.A.

MORGAN
ROLLER STRAIGHTENERS
FOR MERCHANT AND STRUCTURAL MILLS

M C Co

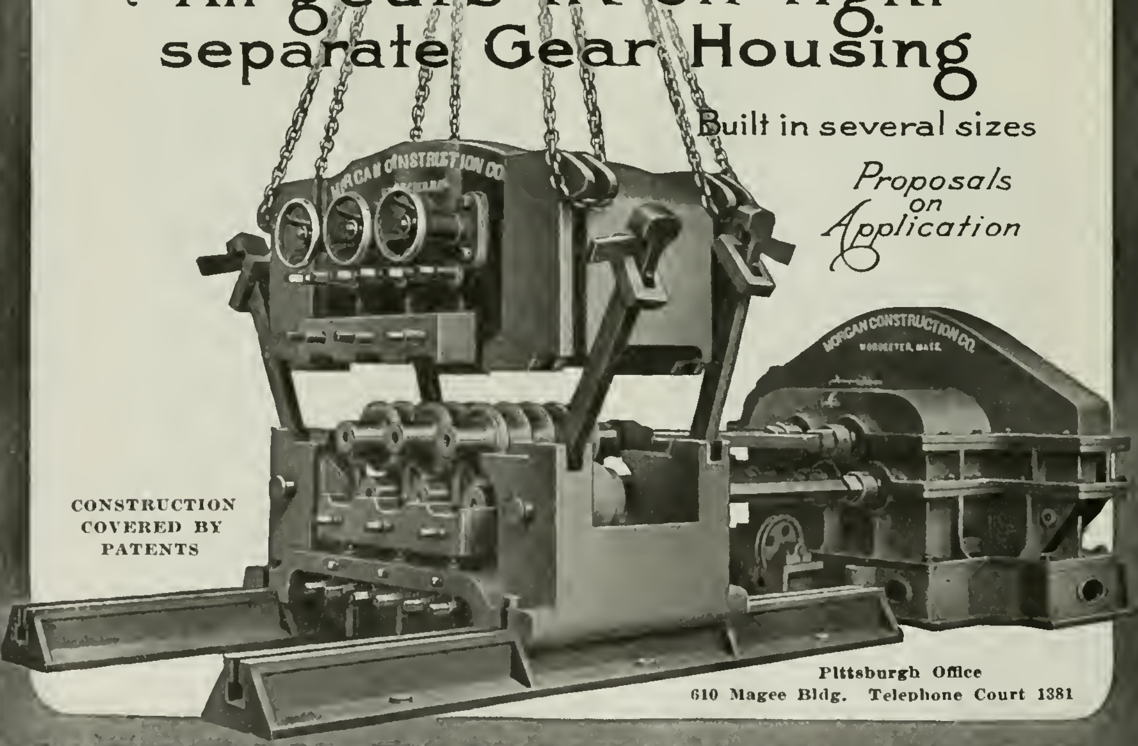
TIME SAVING
All rolls can be changed in
· 20 minutes ·

CONVENIENCE
All roll adjustments from
· the front ·

CONSTRUCTION
All gears in oil tight
separate Gear Housing

Built in several sizes

Proposals on Application



CONSTRUCTION
COVERED BY
PATENTS

Pittsburgh Office
610 Magee Bldg. Telephone Court 1381

MORGAN CONSTRUCTION CO.
WORCESTER MASS. U.S.A.

ADAMITE

(PATENTED)

Where There is Adamite There is Economy

"ADAMITE" Rolls and Castings will decrease ***your*** Operating Expenses, just as they have done and are doing for those who have used this alloy.

It
Has
Established
Performance
Records
and Costs
for

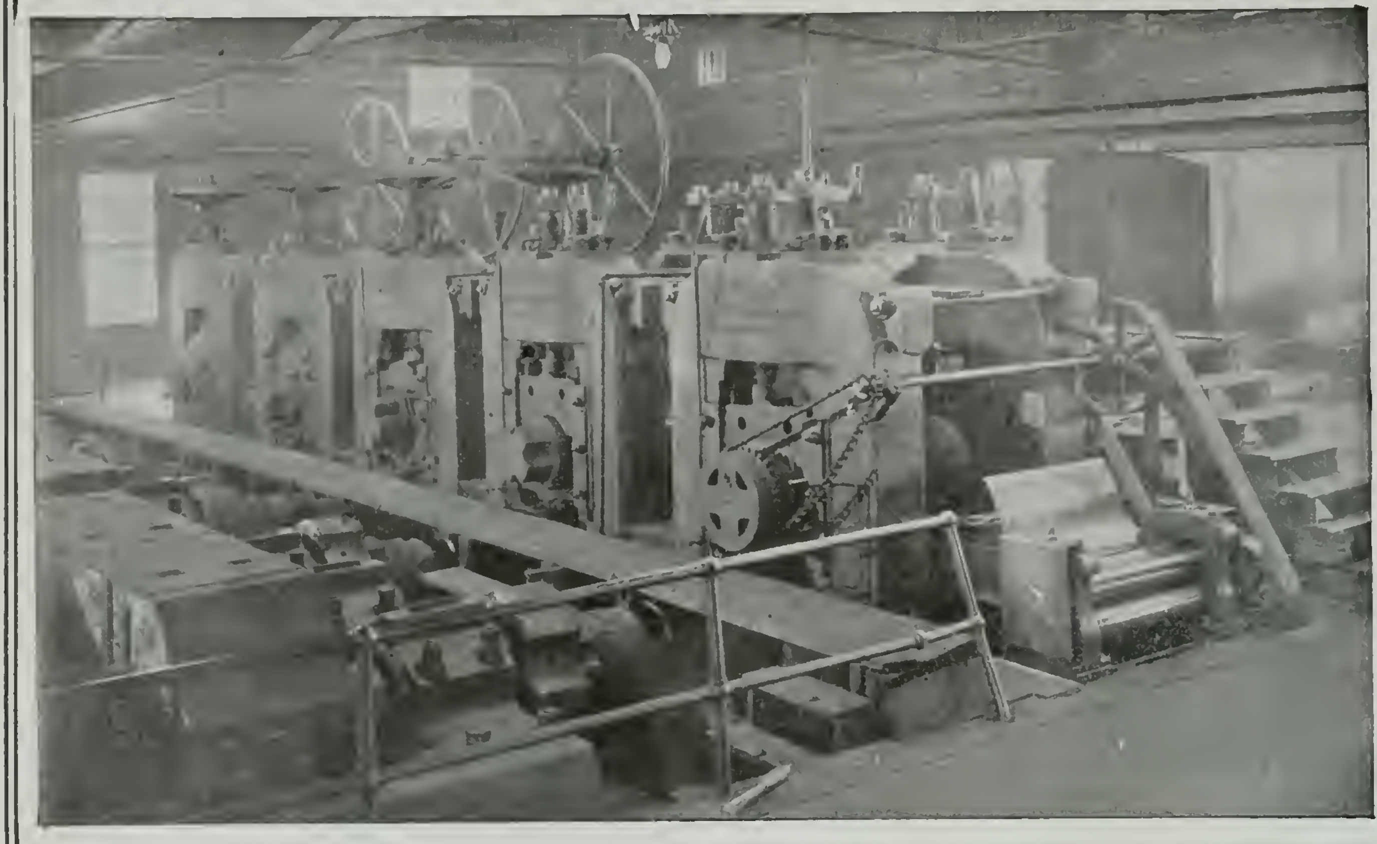
The Best
Superintendents,
the Best
Roll Turners,
the Best
Operators,
the Best
Mill Men
Generally

Don't be misled by—
"JUST AS GOOD AS ADAMITE"

Being ***just as good as "Adamite"***, will never ***make*** it ***"Adamite"***.

Sole Manufacturers:—

Mackintosh-Hemphill Co.
United Engineering & Foundry Co.



26x36-Inch Continuous Cold Rolling Mill

Mackintosh-Hemphill Co.

PITTSBURGH, PA.

Offers You a Complete Service—IN ROLLING MILL AND STEEL WORKS EQUIPMENT—thru its following departments:

Fort Pitt Foundry	**Woodard Machine Co.**
A. Garrison Foundry	**Pittsburgh Iron & Steel Foundries**

Machinery for Iron, Steel, Tube, Zinc, Brass and Aluminum Works—Forging Presses, Shears, Saws, Roll Lathes, Hydraulic Machinery

"MANGANITE"—ROLLS—"ADAMITE"

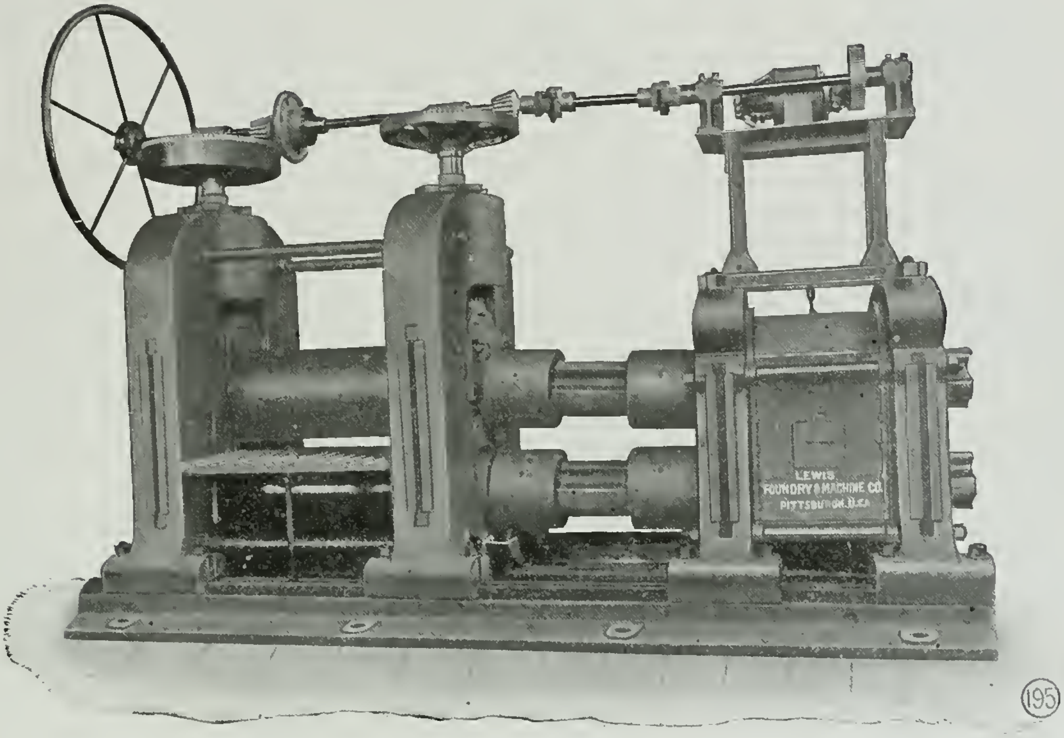
CHILLED, SAND AND STEEL ROLLS

STEEL, IRON AND "ADAMITE" CASTINGS
CAST AND CUT TEETH GEARS AND PINIONS
ANNEALING BOXES AND BOTTOMS

"The Best in Rolling Mill Machinery"

LEWIS FOUNDRY AND MACHINE CO.

FARMERS BANK BUILDING
PITTSBURGH, U. S. A.

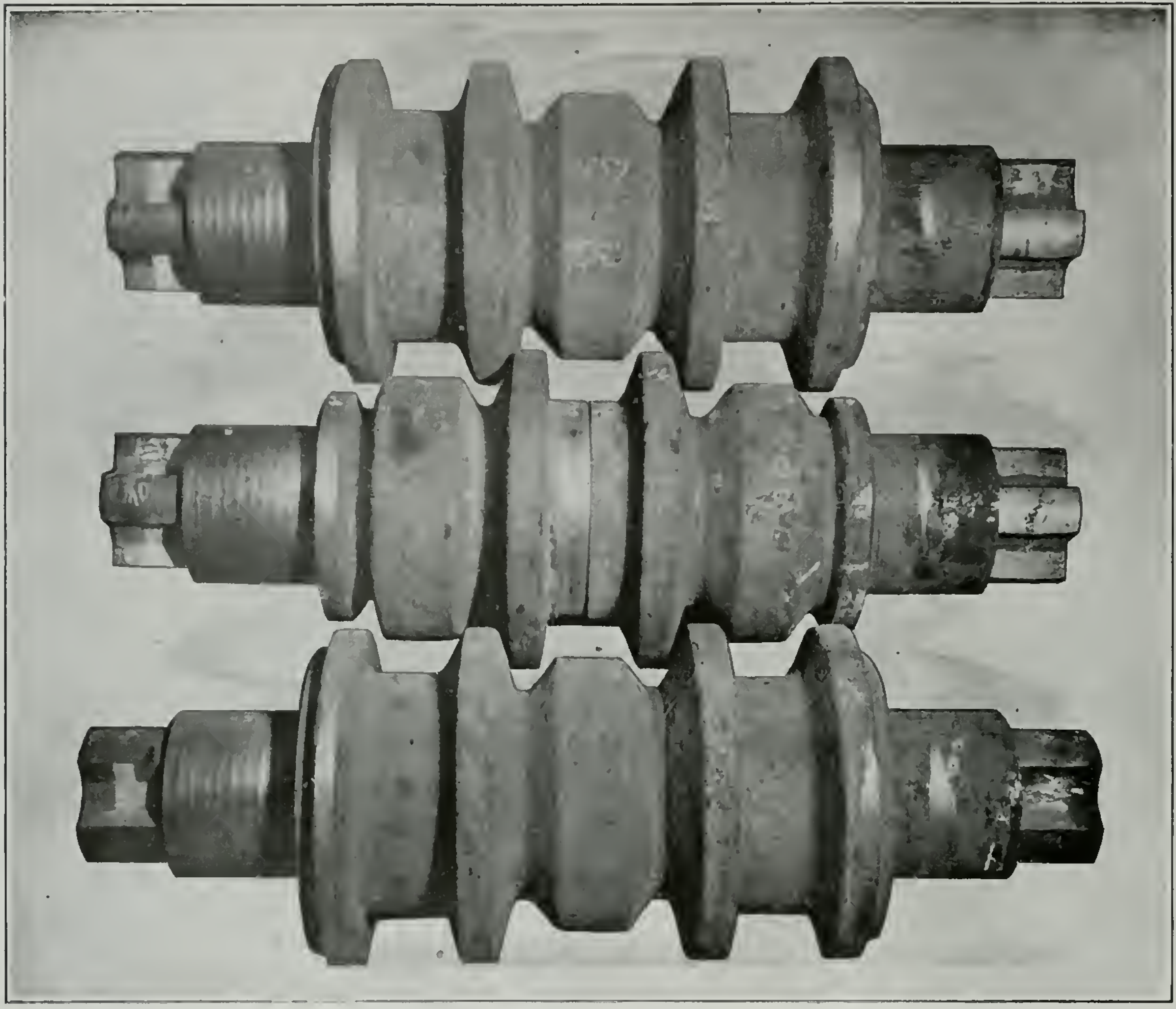


BREAK DOWN MILL WITH MOTOR SCREW DOWN

ROLLS AND ROLLING MILL EQUIPMENT FOR
IRON, STEEL AND NON-FERROUS METALS
SPECIAL MACHINERY

BY INVITATION
MEMBER OF
BE GUIDED BY THIS FOUNDATION
STRENGTH HONOR QUALITY SERVICE
RICE LEADERS OF THE WORLD ASSOCIATION
NEW YORK, U.S.A.

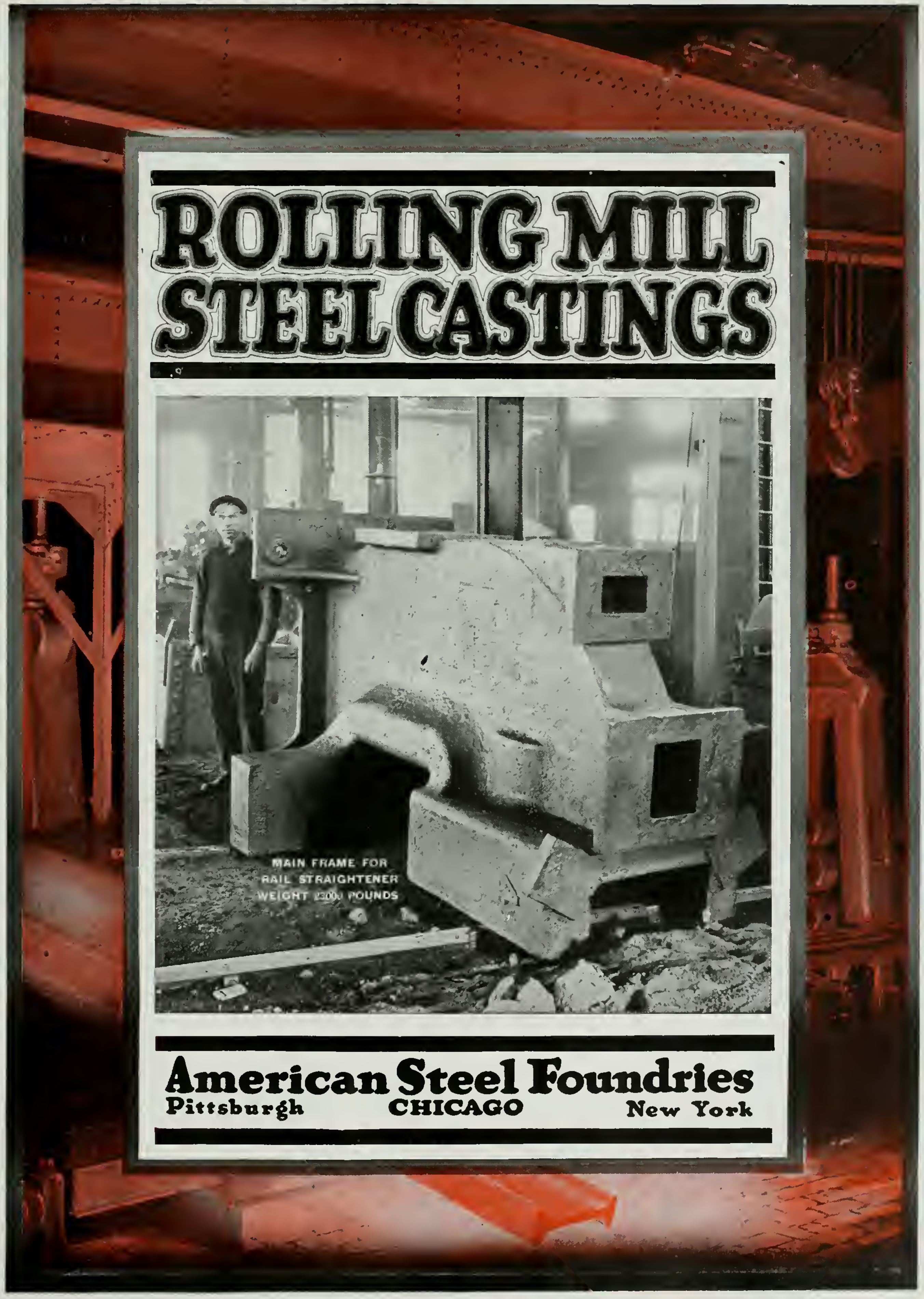
"WHEELING QUALITY"



STEEL ROLLS CHILLED ROLLS
SUPER-STEEL ROLLS SAND ROLLS

Steel Castings
Iron Castings
Special Machinery
Rolling Mill Machinery

Wheeling Mold & Foundry Company
WHEELING, W. VA.



ROLLING MILL STEEL CASTINGS

MAIN FRAME FOR RAIL STRAIGHTENER WEIGHT [illegible] POUNDS

American Steel Foundries

Pittsburgh **CHICAGO** **New York**

NATIONAL

Chilled Sheet and Tin Plate Rolls

FOR HIGH GRADE PRODUCTS

Why Experiment

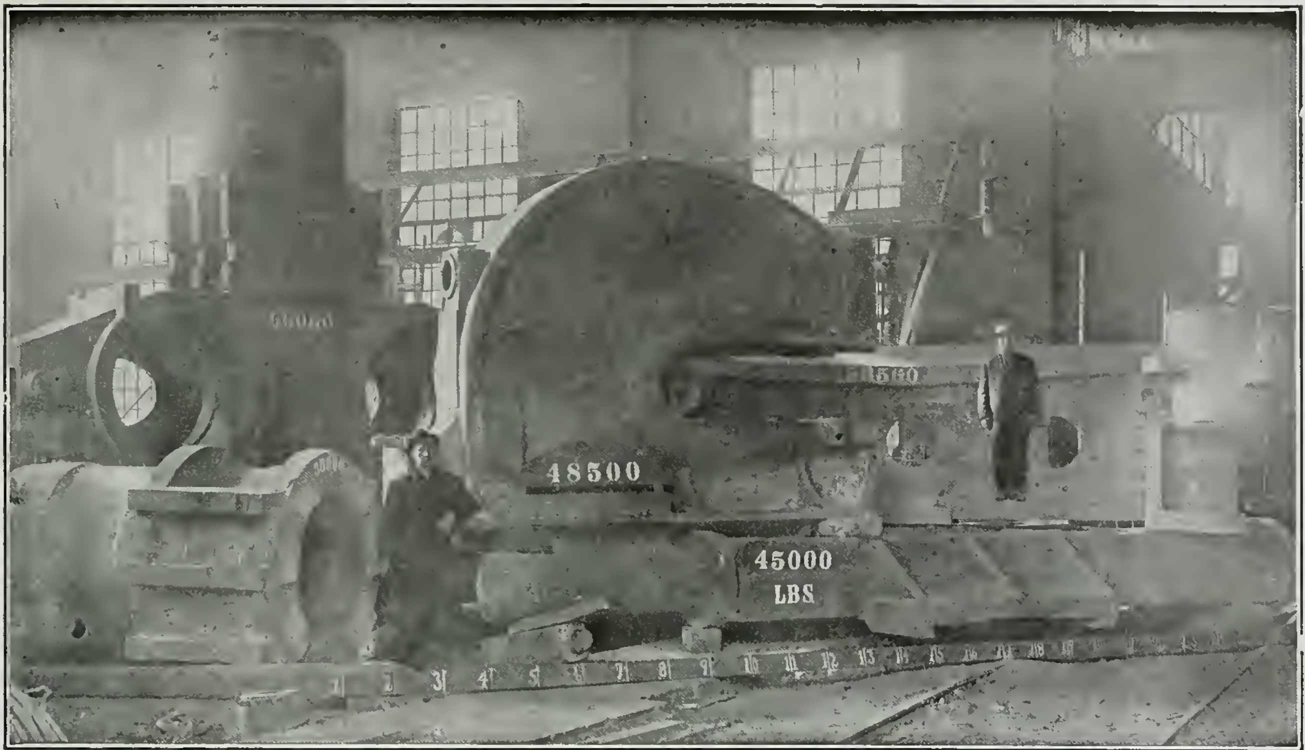
Use the Best

Rolling Mill Machinery Comprising

WEIGHT—RIGIDITY—WORKMANSHIP

NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PA.



BIRDSBORO
STEEL CASTINGS
IRON CASTINGS--INGOT MOLDS

Iron Chilled and Sand --ROLLS-- Alloy and Carbon Steel
Durite (patented)

Blast Furnace Machinery, Rolls, Rolling Mill Machinery, General or Special Machinery, Buchanan Crushers and Concentrating Machinery, Chilled Iron Pump Plungers, Roll Lathes, Jackson Belt Lacing Machines.

Hydraulic Presses and Accumulators

Birdsboro Steel Foundry & Machine Co.,
Birdsboro, Pennsylvania
New York Office, 90 West St., New York City, Room 1710. Tel. Rector 6664-5-6.

CARBON STEEL

"OTISCO"
(Alloy)

OTIS ROLLS

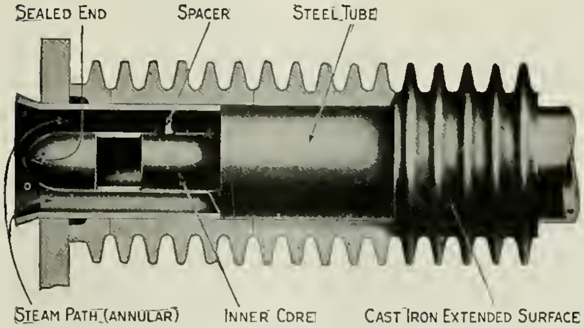
Made to suit Mill Conditions. Otis Rolls are being used in some of the largest Plants in the Country, and have won favor in these Plants by their toughness, hardness, great strength and long service. What they are doing in other Plants they can do in yours.

TRY THEM. THEY WILL REDUCE YOUR ROLL COSTS.

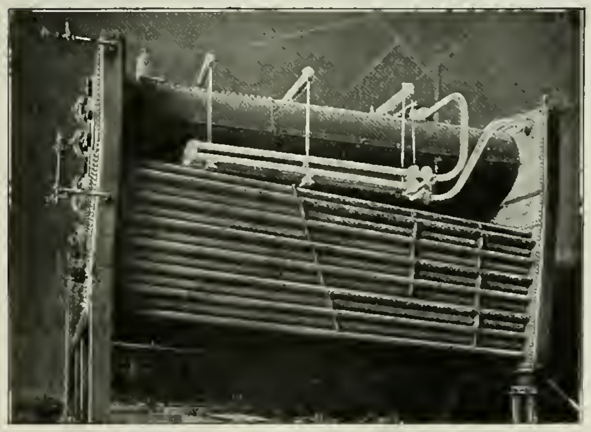
Prompt Deliveries

The Otis Steel Company, Cleveland, Ohio

Superheat!



The Foster Superheater that assures the benefits of superheat with maximum efficiency.



Typical Foster Superheater Construction

You are doing your level best to keep down operating costs. But whichever way you turn, you are faced by handicaps—high fuel costs, poor grades of fuel, inefficient help, insufficient capacity, high costs of supplies and replacements. Your problem is how to improve your plant economy so as to win out over present-day conditions.

Superheat Your Steam!

Have you investigated the benefits of superheat? Take your engines, for example. Superheat reduces the amount of steam they will require by about 1% for every 12 degrees in the case of turbines and to an even greater degree in the case of reciprocating engines. And superheat helps engine operations in another way—by eliminating the condensation that slows up turbines and washes the lubricating oil off engine cylinder walls.

Properly designed superheaters also improve boiler efficiency.

This is proven by the fact that Foster Superheaters invariably increase the capacity of boilers for work and reduce stack temperatures.

You will find that new and up-to-date power plants—the plants that are making records for economy—are using superheated steam. And remember that the advantages of superheated steam are even greater in small or old or uneconomical plants.

Foster Superheaters assure the full benefits of superheat with least maintenance. Foster construction meets superheater service conditions with a unique combination that has proven faultless for 20 years — a steel tube to carry pressure expanded into a cast iron extended surface on the exterior to resist corrosive furnace gases and to greatly increase the surface exposed to these gases for the collection and storage of heat.

Let us show you how Foster Superheaters will help you improve your plant efficiency. A postal card will bring full information.

POWER SPECIALTY COMPANY
111 Broadway, New York
Boston Philadelphia Pittsburgh Chicago San Francisco
Kansas City Dallas London, England
Plants at Dansville, N. Y., and Egham, England

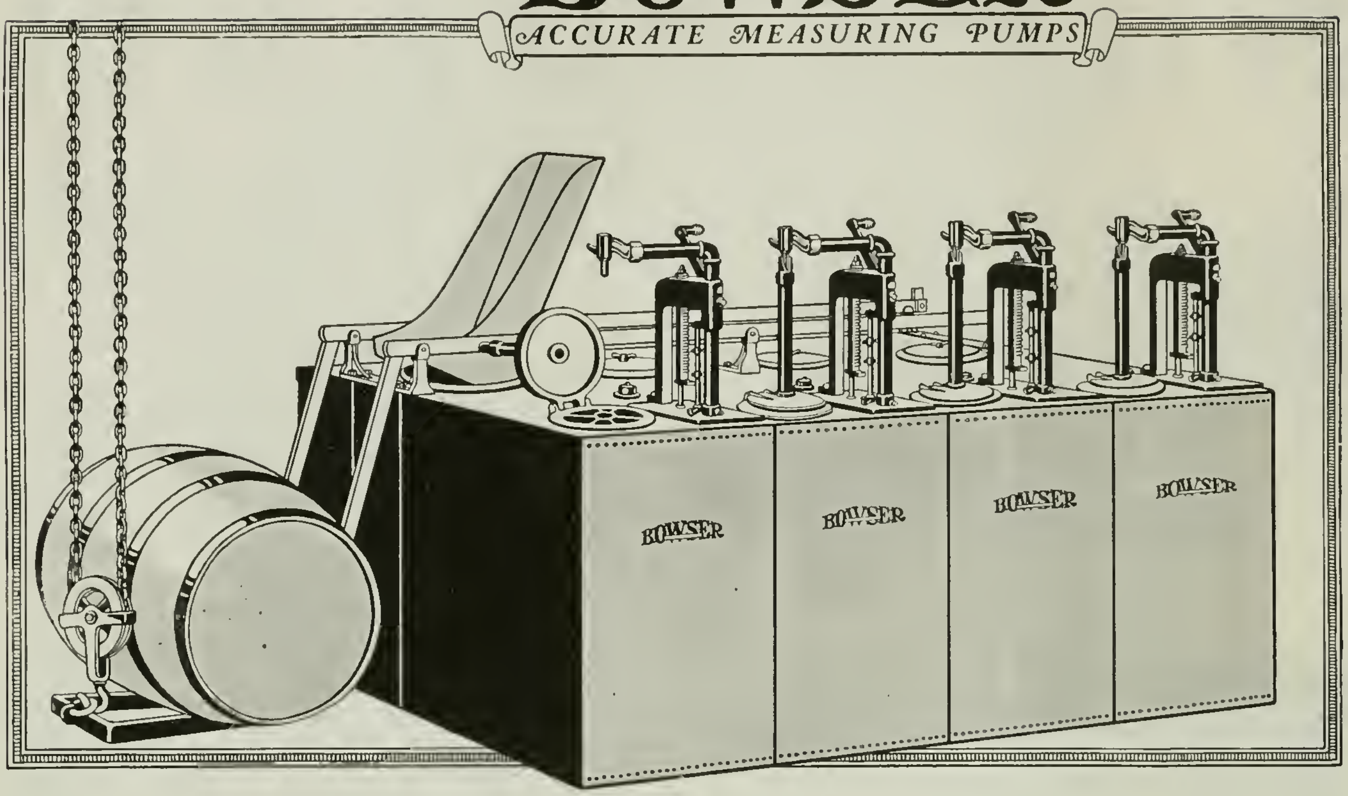
20

FOSTER SUPERHEATERS

BOWSER

ESTABLISHED 1885

ACCURATE MEASURING PUMPS



"What Did the Inspector Say, Bill?"

"What he said about the way we handle our oils was aplenty, Jim," answered Bill. "He said those leaky drums scattered all over the plant made the worst kind of a fire risk. And that means the company is forced to pay the maximum rate —all because we don't have proper oil storage."

Many a plant has cut its insurance load by installing Bowser equipment, which insures minimum rates by eliminating fire hazards. The saving on insurance, plus the saving on oil, will pay for the whole equipment.

Moreover, Bowser systems eliminate waste, check purchases, measure every drop used, cut labor costs to the very lowest point—and do their full part in insuring better lubrication and fewer mechanical troubles.

Booklet A-05, which we will gladly mail, tells the story. Better still, ask our engineers to make a survey of your plant and prove what a Bowser system will do for you. Start your drive for production economy by writing us today.

Bowser Products
For Handling Gasoline and Oils Wherever Sold or Used

- Filling Station Pumps and Tanks for Gasoline.
- Portable Tanks for Oil and Gasoline.
- Storage and Measuring Outfits for Paint Oils, Kerosene and Lubricating Oils.
- Carload Oil Storage Tanks.
- Power Pumps.
- Dry Cleaners' Underground Naptha Clarifying Systems.
- Richardson-Phenix Oil Circulating and Filtering Systems and Force Feed Lubricators.

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Home Plant: Fort Wayne, Indiana • Canadian Plant: Toronto, Ontario
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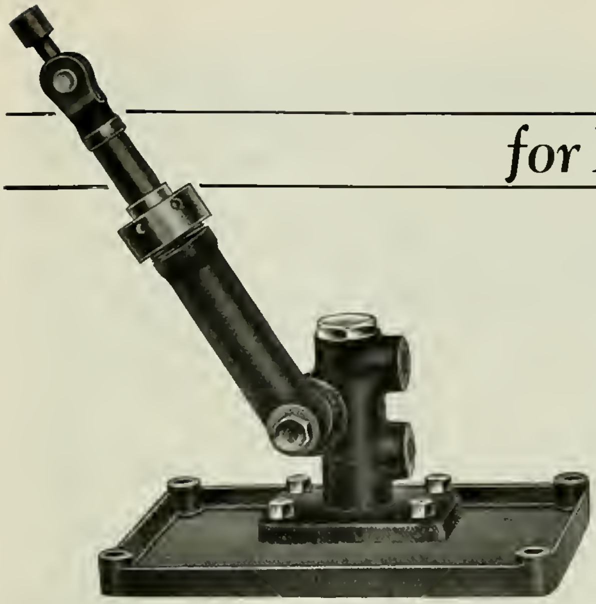
PUMPS

for Fuel and Lubricating Oils



Inclinable Plunger Pump

Capacity ranges from 0 to 40 gals. per hour. Operated by some moving part of engine or machine. Plunger may be inclined to any angle to facilitate installation. Unexcelled for use in small circulating systems on machine tools, small steam engines, etc

Large Small
Motor Drive Belt Drive Engine Drive
Simplex Duplex Triplex
Single Units Multiple Units

Capacities—from 0 G. P. M. up to 250 G. P. M. per unit

In other words—we have just the pumping unit to do that pumping job of yours. No matter how small—no matter how large.

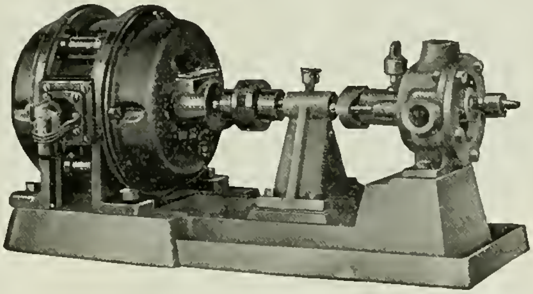


Fig. 1709—Motor-Driven Rotary Pump

Available in sizes of 3/8 in. up to and including 3 in. Capacities from 0 to 250 gals. per min. 1/8, 1/2 and 3/4 in. sizes direct connected to motor. Larger sizes include reduction gears. For heavy duty service in loading tank wagons from underground storage, circulating and general pumping requirements the Fig. 1709 is daily standing the gaff.

Our line of oil pumps is complete as we meet varying conditions in supplying Oil Filtering, Purifying and Distribution equipment for Steam Turbines, all types of prime movers, Steel Mills, and other services. Our Lubrication Engineers are at your service.

Tell us your oil pumping needs—we'll meet them with guaranteed pumping equipment.

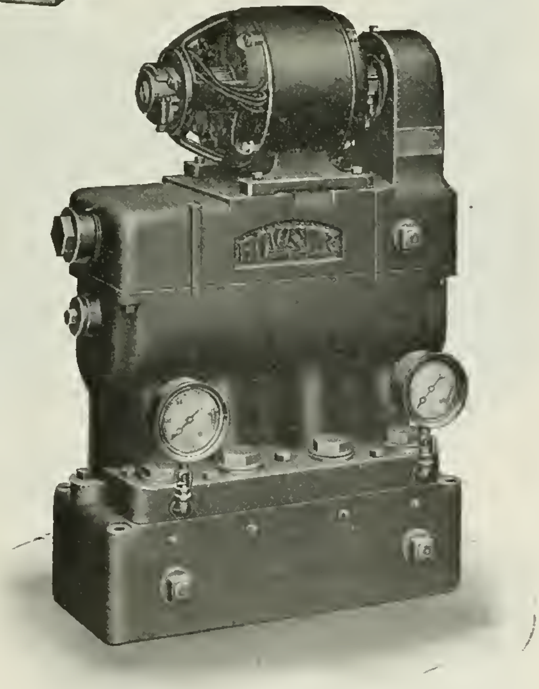


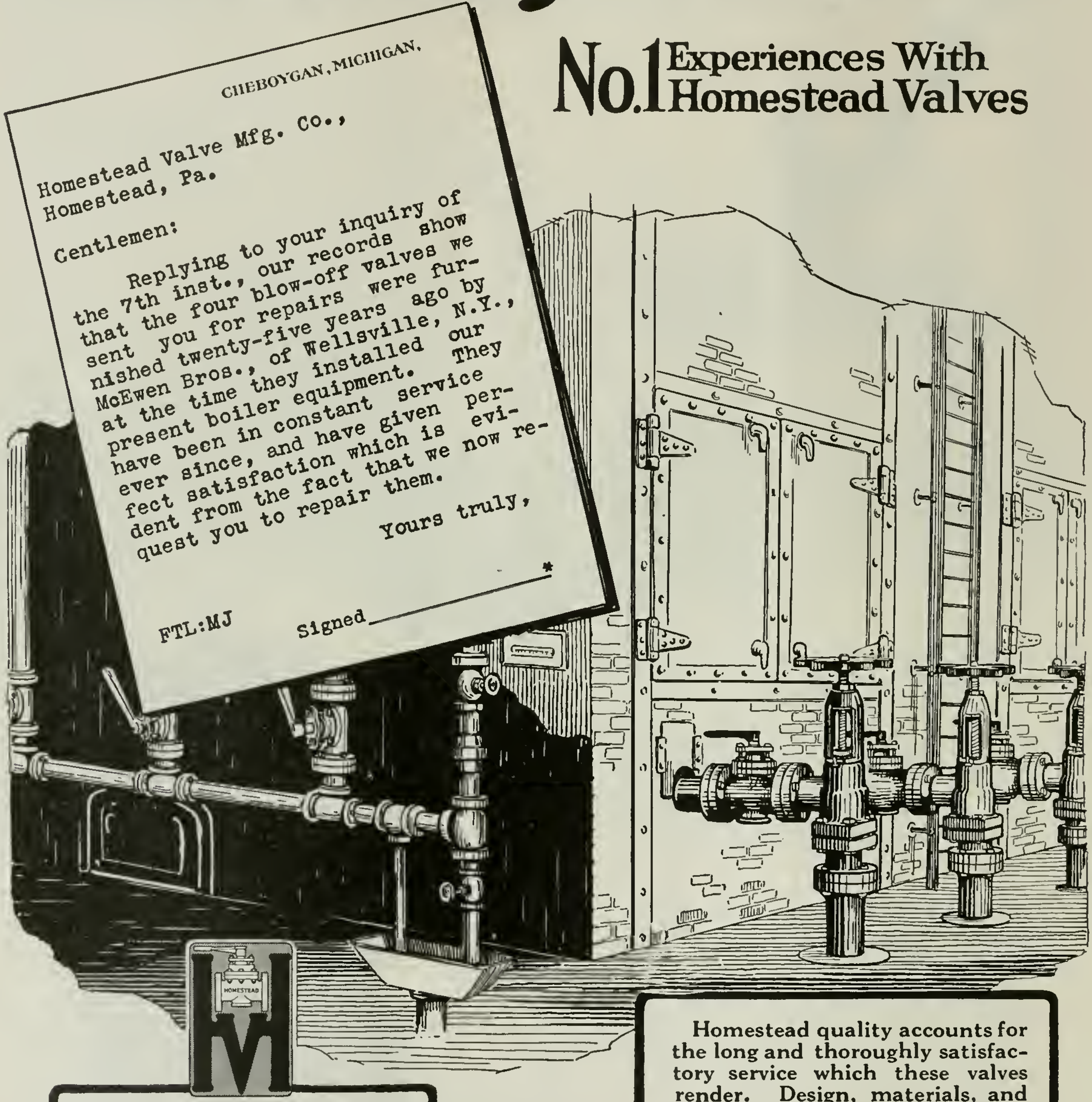
Fig 10-F-507 Double-Acting Electric Driven Pump

The favorite of steel mill engineers. All parts working in a bath of oil, operation practically noiseless. For long uninterrupted, satisfactory pumping service, choose the 10-F-507.

THE RICHARDSON-PHENIX DIVISION
S. F. BOWSER & CO., INC.
LUBRICATION ENGINEERS AND MANUFACTURERS
FORT WAYNE INDIANA

After Twenty-five Years

No. 1 Experiences With Homestead Valves



CHEBOYGAN, MICHIGAN.

Homestead Valve Mfg. Co.,
Homestead, Pa.

Gentlemen:

Replying to your inquiry of the 7th inst., our records show that the four blow-off valves we sent you for repairs were furnished twenty-five years ago by McEwen Bros., of Wellsville, N.Y., at the time they installed our present boiler equipment. They have been in constant service ever since, and have given perfect satisfaction which is evident from the fact that we now request you to repair them.

Yours truly,

FTL:MJ Signed ______*

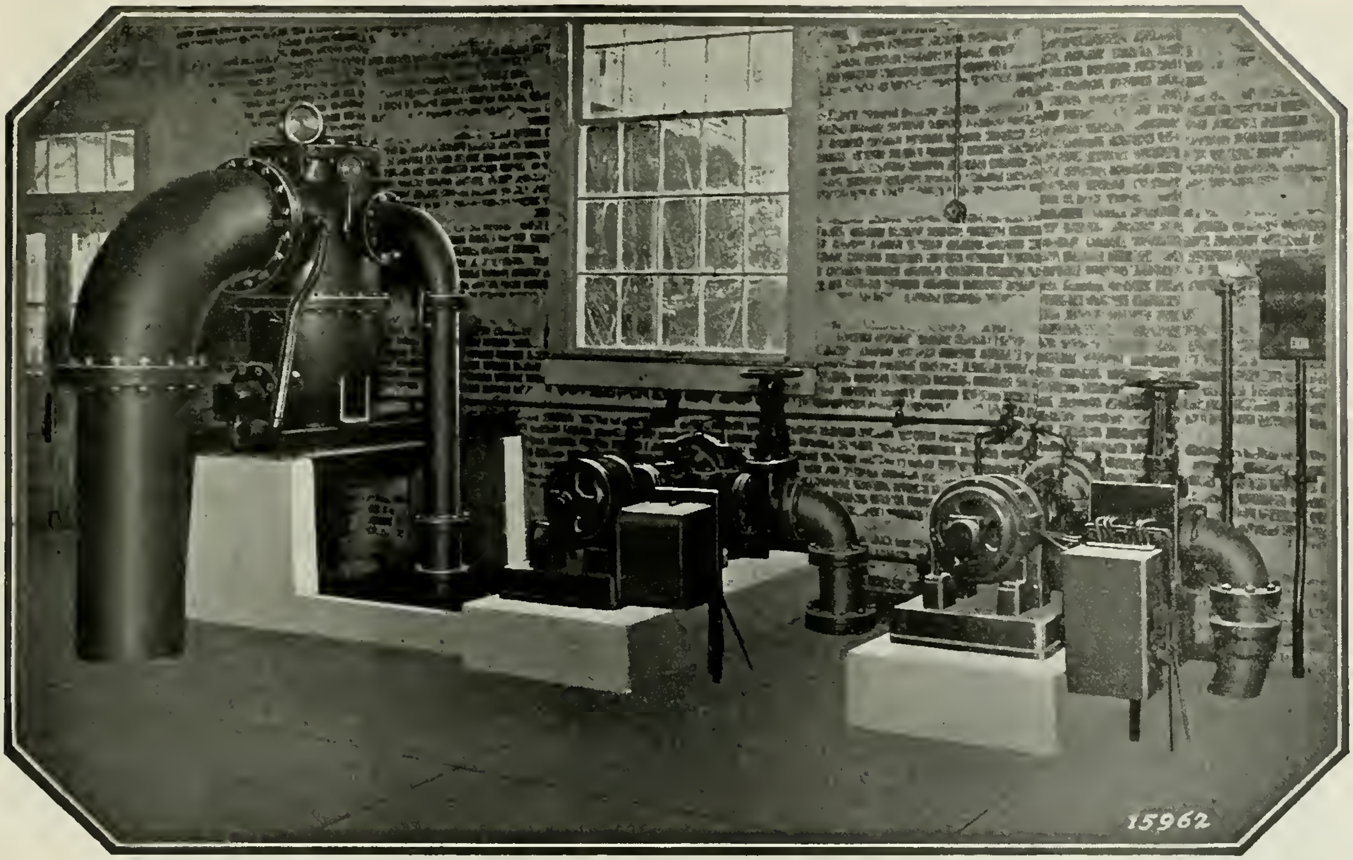
Other Interesting Experiences from Homestead users are solicited. In return for a letter covering *your* experience we will mail you a handsome leather pocket-size note-book with renewable pad.

**Name Sent on Request*

Homestead quality accounts for the long and thoroughly satisfactory service which these valves render. Design, materials, and workmanship, are all of the highest standard.

Homestead Valve Mfg. Co.
135 Sixth Ave. Homestead, Penna.

HOMESTEAD



The Simplest Condenser
for all size engines and turbines

The one most striking feature of the Ingersoll-Rand Low Level Multi-Jet Condenser is simplicity. Only one standard cold water injection pump is required, eliminating the inaccessible removal pump usually located under this type of condenser.

NO AIR PUMP IS NEEDED as the air and vapors are removed by the ejector action of the condensing water.

An Ingersoll-Rand Low Level Multi-Jet Condenser can be installed anywhere to suit such conditions. It is the simpest type for all size engines and turbines.

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18-LLJ

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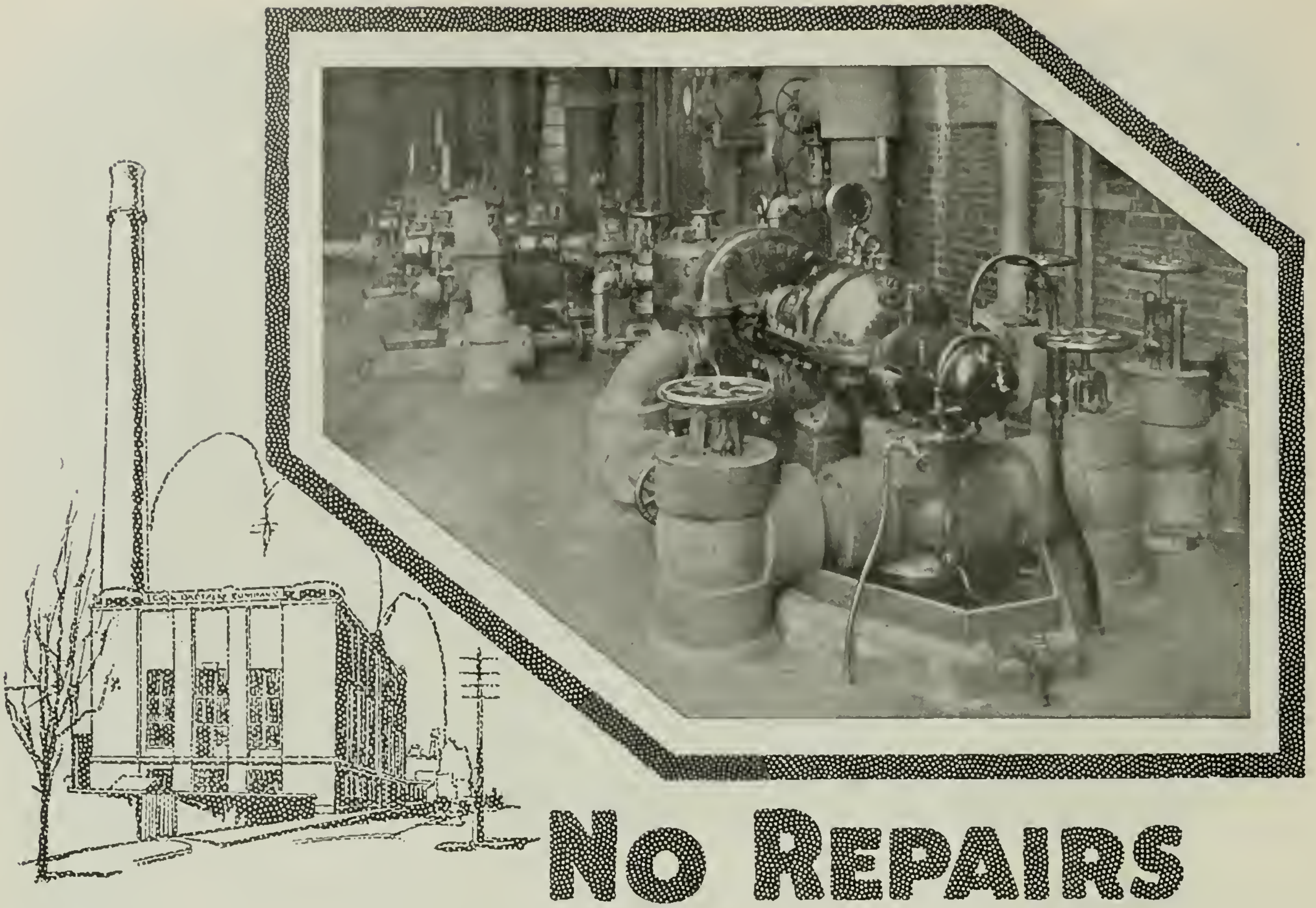
Low Level Multi-Jet, Barometric and Surface Condensers



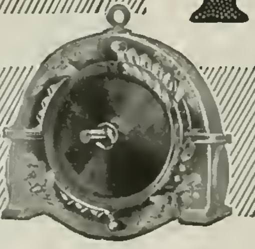
NO REPAIRS

"PERFECTLY satisfactory and no repairs." This is the statement from the engineer in charge of the Terry Turbines, installed at the Lever Bros. Co., Cambridge, Mass. This is not typical of all Terry turbine installations, for it must be recalled that Terry turbines were being manufactured over twenty years ago. There is no moving mechanism built, which will run forever with out replacing the wearing parts, and the Terry turbine is no exception to this rule. For this very reason The Terry Steam Turbine Company maintains a very complete and extensive stock of repair parts ready for immediate shipment and a force of trained men in the field for the purpose of making replacements when necessary. The fact that Lever Bros. have as yet made no repairs is significant of the fact that Terry turbines with the proper attention to lubrication and adjustment are free from operating kinks and troubles and will continue to give good service during the calculated life of their wearing parts.

Write for Bulletin No. 25-A, which contains a complete detail of these working parts and loads and stresses imposed upon them. You will then appreciate how small your replacement charges will be, should you select

T-777

THE TERRY TURBINE



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in U.S.A. also in Important
Industrial Foreign Countries

The Terry Steam Turbine Co.
Terry Sq. Hartford. Conn. U.S.A.

Don't Blame the Coal If You Can't Hold Your Steam

In all probability your boilers are not adapted to steam economically on the poor grades of coal you are forced to accept.

Their design was never intended to allow for the furnace volume and grate surfaces required for the efficient combustion of these coals.

Bigelow-Hornsby Water Tube Boilers

are of the vertically inclined straight tube, sectionalized design, which permits the furnace to be readily proportioned to any fuel requirement.

They operate continuously at high economy with maximum flexibility up to very high over-ratings. Cleaning and repair costs are exceptionally low.

A paying investment for any plant. Why not investigate their design?

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Established 1860
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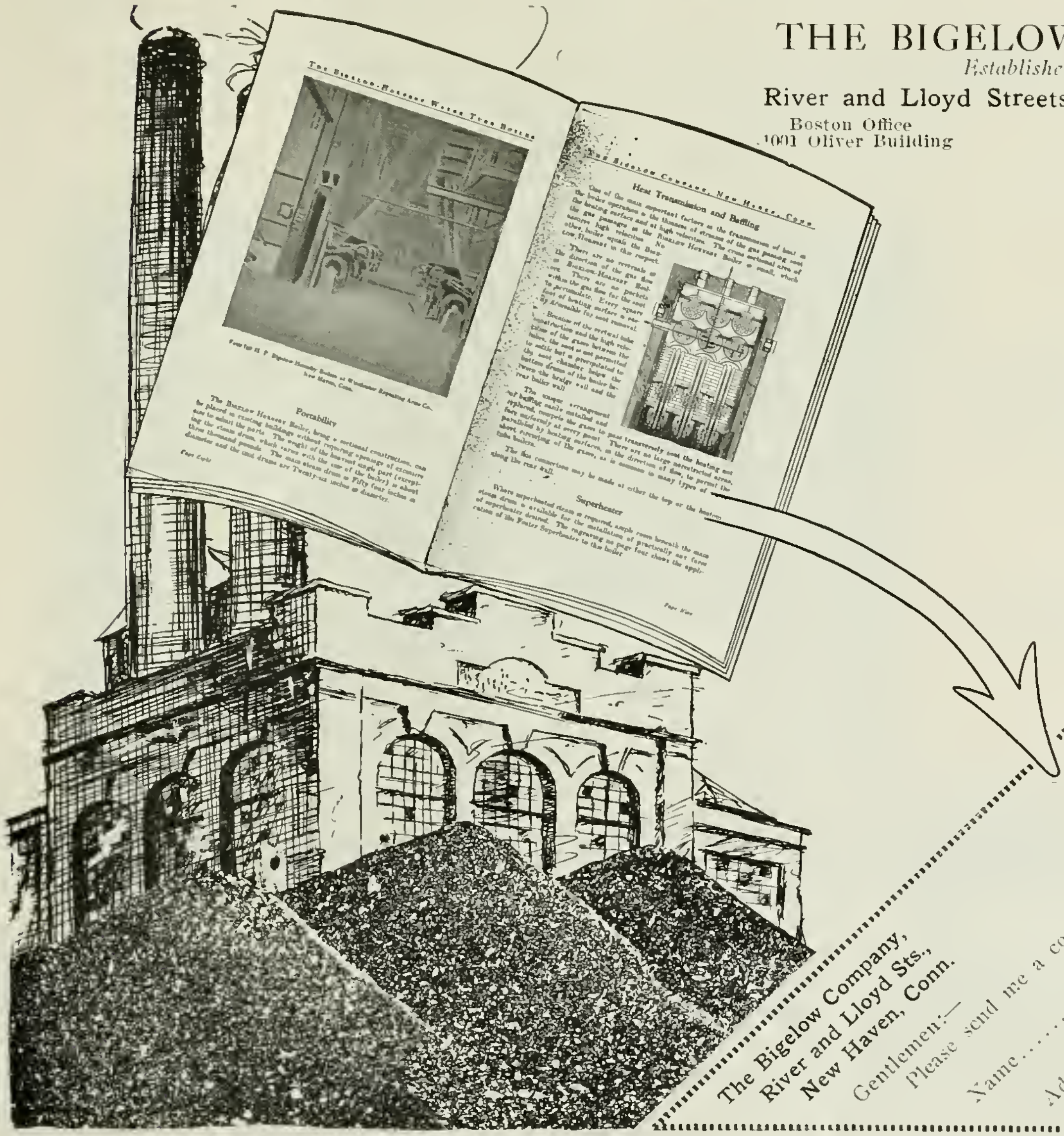

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Four Points—

More than twenty-three years ago Coxe Stokers blazed the way in the efficient burning of anthracite coal on an automatic stoker.

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Today Coxe Stokers are stokers of universal service for all low grade fuels.

The above is the sub title page of a new book on the forced draft traveling grate stoker that is doing the big business in its field—Send for it; it's interesting.

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Combustion Engineering Corporation

Combustion Engineering Bldg.—43 Broad Street New York City
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EDGE MOOR Water Tube BOILERS

THE protracted coal strike of the past months emphasizes the ever-present need for fuel economy. The importance of obtaining the utmost return from every fuel dollar is no less in times of industrial peace.

Fuel economy begins and centers in the boiler room. The boilers themselves are the most important factor in any program of fuel saving.

Edge Moor Water Tube Boilers are built for the express purpose of utilizing every possible B. T. U. in the fuel burned under them. The unrestricted connection between header and drum that is a feature of Edge Moor Boilers gives them exceptional capacity for quick steaming. Fluctuating loads and high overloads can be carried without damage or loss of efficiency.

The Edge Moor catalogue explains the important features of this boiler that contribute to fuel economy. Your request will bring a copy promptly.

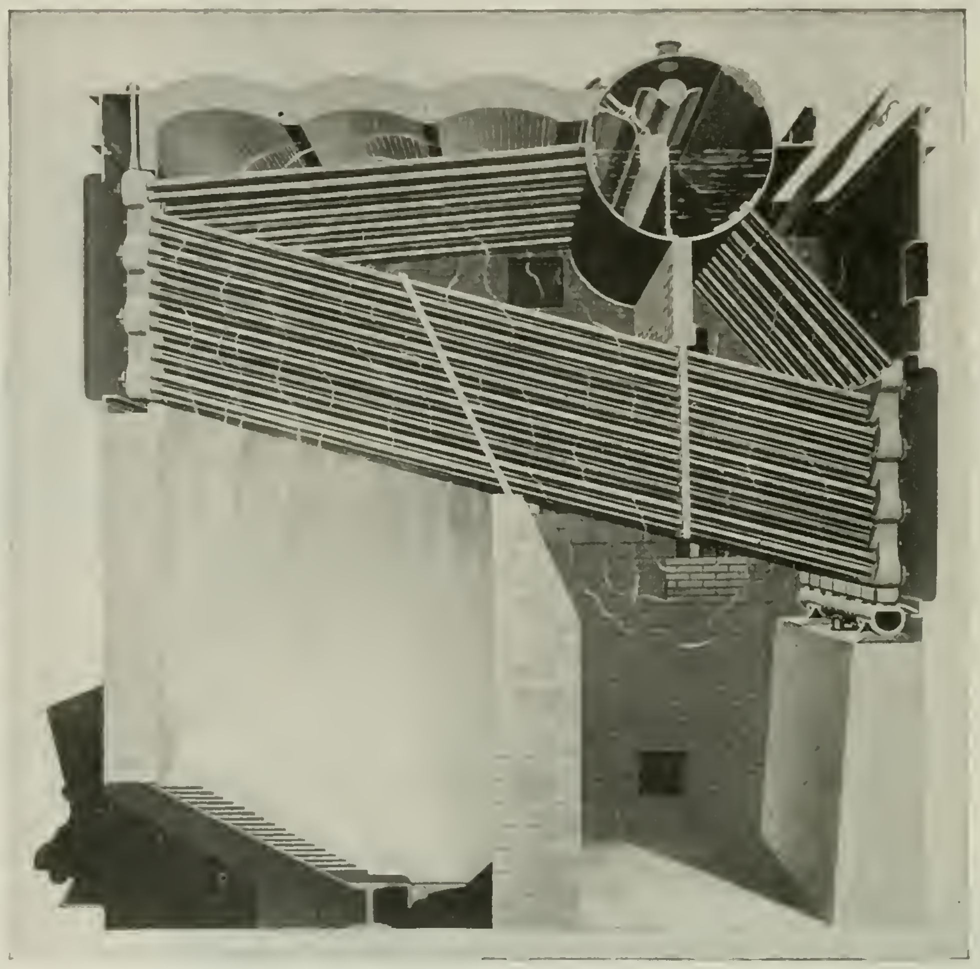
EDGE MOOR BOILERS EDGE MOOR, DEL. U.S.A.

EDGE MOOR IRON COMPANY
Established 1868
EDGE MOOR, DELAWARE
New York *Chicago* *Boston* *Pittsburgh* *St. Paul* *Charlotte*

Twelve 556 H. P. Edge Moor Boilers with chain grate stokers in the plant of the A. E. Staley Mfg. Co., makers of starch.

Below: General view of the Staley Company's plant at Decatur, Ill.

FOR INCREASED FUEL ECONOMY



SPRINGFIELD CONSTRUCTION

Affords a steam liberating area and circulation over the entire length of the steam drum. Dryer Steam is produced than by other types of boilers.

Provides a tube spacing that places all tubes in the direct path of the combustion gases, and insures a low escaping gas temperature.

Makes circulation positive and steaming rapid. Perfect flexibility in operation.

Has been accepted by large power users as a standard in design and workmanship.

Sizes to 3,000 HP.—Pressures to 500 lbs.

Our catalog which goes into detail may be had for the asking.

SPRINGFIELD BOILER CO., Springfield, Ill.

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Chicago	Philadelphia	Buffalo	Minneapolis	San Francisco
New York	Pittsburgh	Detroit	Kansas City	Cleveland
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Where the Quality Product is Made
Standard Practice Calls for Kellogg Annealing Pots

No Air Leaks.

With a cast pot—of whatever material made—a concealed blow hole is apt to develop at any time. And, in accordance with the usual perversity of inanimate objects, the leak almost invariably develops when you are running a heat on watch springs, fine wire or something that means real money—and the entire batch must be reworked from start to finish.

But—

The close-grained structure of the Kellogg Annealing Pot, Forge Welded from special plate steel, absolutely defies air leakage, while the annealing furnace itself cannot find the difference between the weld and the original plate.

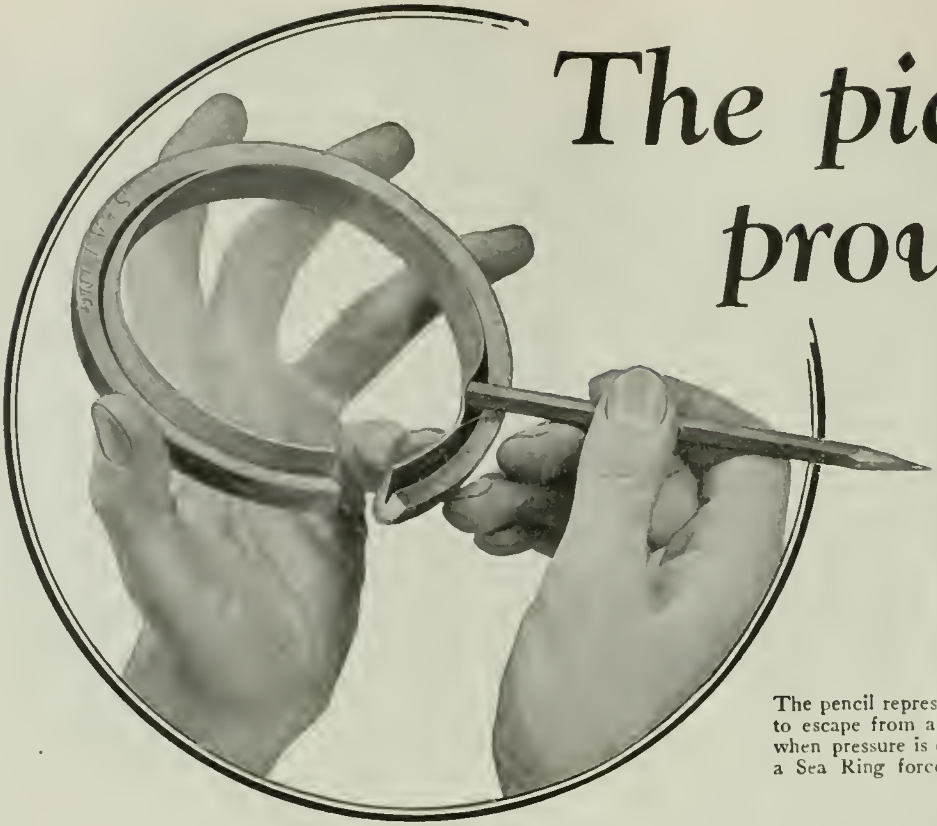
They cannot crack. They cannot leak. They are built for the manufacture of the quality product.

Ask us what we mean by "1 to 4 cost ratio."

The M. W. KELLOGG Co

90 West St. New York City

The picture proves it



Here's a rod packing that packs only when it ought to

The pencil represents pressure tending to escape from a stuffing box. Only when pressure is exerted, is the lip of a Sea Ring forced against the rod.

How Sea Rings work

The reason the Sea Ring packs only when it ought to and whenever it ought to, is because its design provides for a hollow space where pressure may accumulate and act on a flexible lip that lies against the rod.

When there is no tendency of leakage through the stuffing box, this lip is not pressed against the rod.

Tendency of leakage or pressure, however, forces it against the rod. And note this—the grip on the rod is in proportion to the pressure, with never any more force than is necessary.

The automatic action of the Sea Ring checks power loss, spares rods, lengthens the life of packing and eliminates wasteful friction.

JOHNS-MANVILLE Inc.
Madison Avenue at 41st Street, New York City
Branches in 56 Large Cities
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Perfectly simple—simply perfect

Simplicity is the keynote of the Johns-Manville Steam Trap. It works because it has nothing to get out of order. A hollow copper ball is the only moving part. As water flows into the trap, the ball rolls up, exposing the outlet—and so water and air are discharged. For sure action, count on this Steam Trap.

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Through—
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and its allied products
INSULATION
BRAKE LININGS
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PACKINGS
CEMENTS
FIRE PREVENTION PRODUCTS

JOHNS-MANVILLE
Power Plant Materials

Diamond Valv-In-Head Soot Blowers

WITH Diamond *Valv-in-Head* soot blowers the number of manual operations is very greatly reduced and opportunity for errors in those performed is extremely limited.

Proper Speed of Rotation Assured: Boilers are only effectively cleaned when the steam jets play on the tubes for a predetermined period of time. With the Diamond *Valv-in-Head* soot blower the reduction gear so regulates the speed of the blower element that all tubes are equally and thoroughly cleaned.

Ease of Operation: The unit is full floating, eliminating any possible binding and sticking. A ball thrust bearing assures easy rotation under all steam pressures. As the blower element turns readily with a slight pull on the chain, efficient regular operation is a matter of course.

As with previous mechanical soot blowers the use of the Diamond *Valv-in-Head* effects a saving of four to eight per cent fuel. As compared to previous mechanical soot blowers the Diamond *Valv-in-Head* possesses the following distinct advantages:

1. *Labor for Operation*—A saving of approximately fifty per cent.
2. *Steam for Operation*—A saving of fifty to sixty per cent, or more.
3. *Pipe, Valves and Fittings*—A saving of fifty to sixty-six per cent in cost of pipe, valves and fittings.

Remember that Diamond blower elements used in the hot passes of water tube boilers are CALORIZED.

One of the most interesting publications in the power plant field is the bulletin describing Diamond *Valv-in-Head* soot blowers.

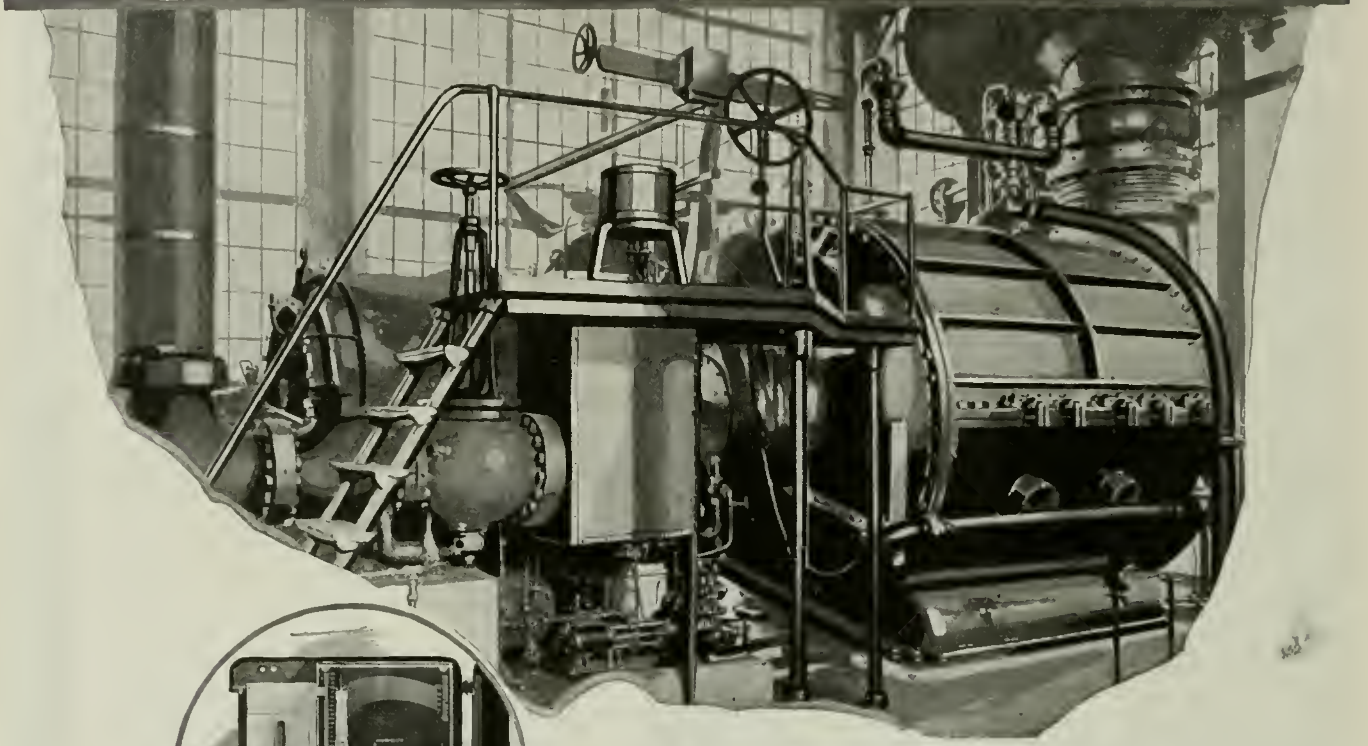
To secure your copy ask for Bulletin 257

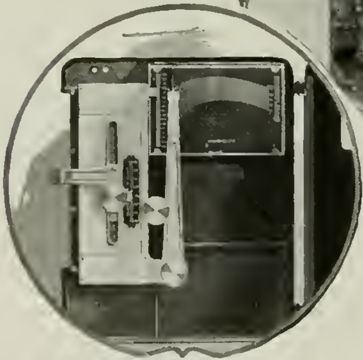
Diamond Power Specialty Corporation

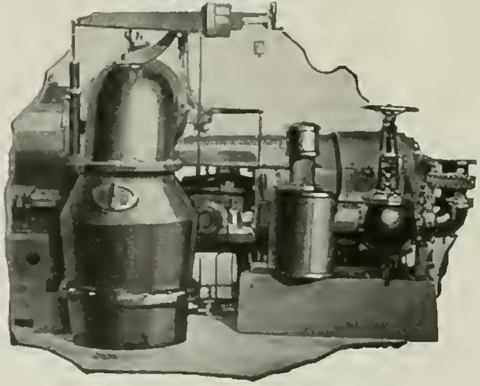
Detroit, Michigan, U. S. A.

Eliminate the Human Factor

Steadier and accurately measured blast gives better conditions in the blast furnace, which leads to increased output and improved quality







For most efficient service use G-E Centrifugal Blast Furnace Blowers

The G-E blower pictured above provides air for a 600 ton furnace, and offers a method of attaining better furnace conditions which is attended with lower first cost and lower operating cost as compared with the apparatus it displaces.

A further advantage consists in providing an accurate measurement of flow of air into the furnace as contrasted with the inaccuracies of estimation by displacement.

Uniform furnace conditions are maintained by virtue of the accurate constant volume governor shown in the illustration at the left and its volume corrector, an enlarged picture of which is in the circle just above the governor.

G-E Centrifugal Blowers operate with less attention and are more flexible in service than any other form of blowing apparatus for blast furnaces. Further details may be obtained from the nearest G-E office.

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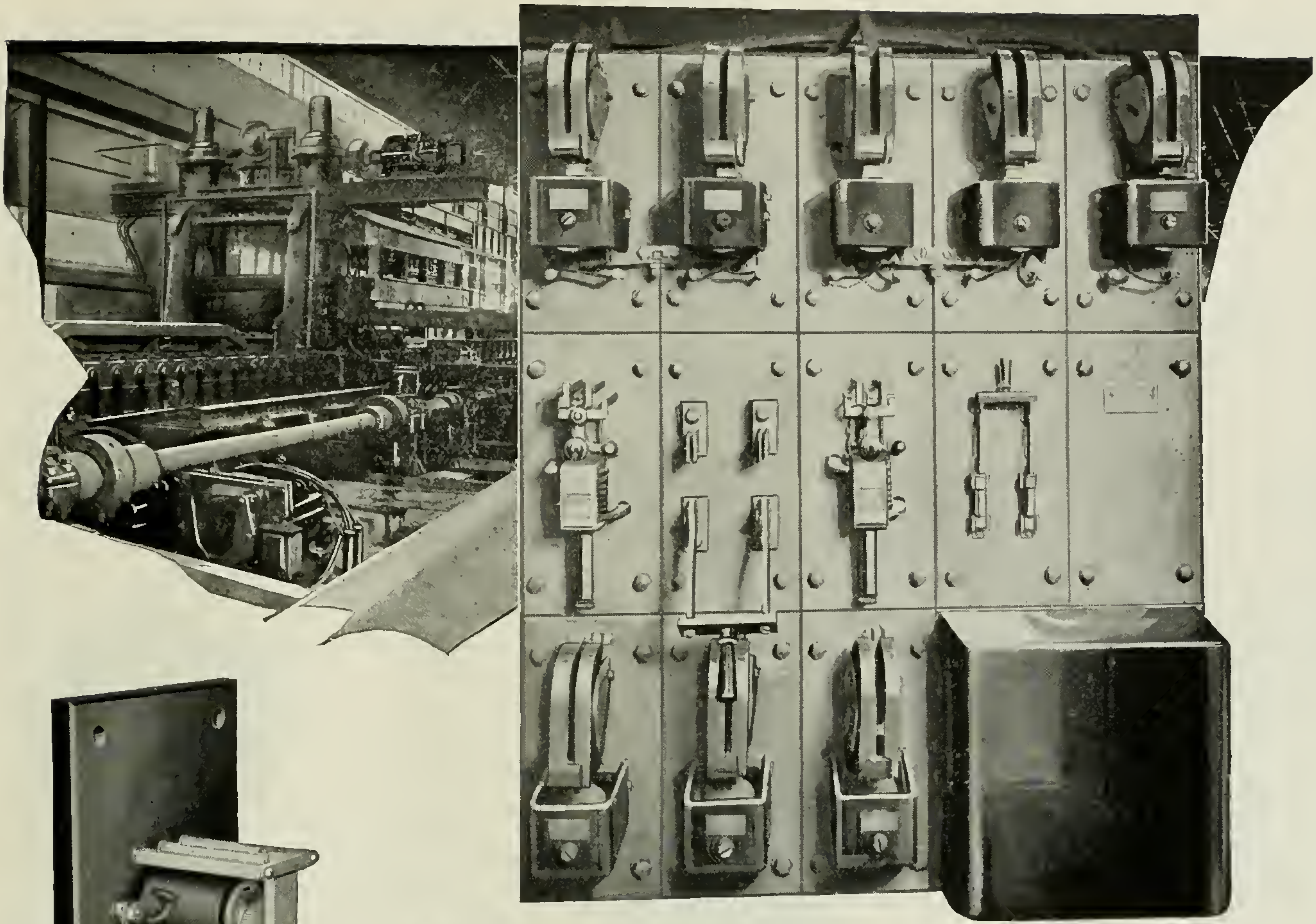

Voltage-drop Relay

Interchangeability

The Voltage-drop Relays, complete with coils, are identical for any line voltage—independent of the size of the motor.

It is a simple matter to adjust these relays on the panels or in the shop for any motor in the mill for which the number of accelerating-contactors is known.

On any control panel the line-contactors and accelerating-contactors, complete with coils, are identical and are therefore interchangeable.

Voltage-drop Control Improves DC Motor Drives

The operation of motors driving Steel Mill Auxiliaries and Crane Equipments has been bettered unquestionably by the System of Voltage-drop Control developed by the General Electric Company. Installations of this equipment (one of which is shown above) in the most exacting service on Screw-Downs, Approach-Tables, Coal and Ore Bridges, etc., have proved their remarkable efficiency and reliability to the complete satisfaction of their users.

G-E Voltage-drop System of Control provides combined current-limit and time-limit acceleration—which permits the high current peaks necessary for accelerating a heavy load, but automatically limits them to much lower values when the load is light.

G-E Voltage-drop Controllers employ only parts that are extra strong, mechanically and electrically. All parts are easily accessible, and a great many are interchangeable. The current-limiting apparatus is separate from the contactors and operates on voltage instead of current.

Ask the nearest G-E Sales Office for complete details

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43A-72

FRANCKE
FLEXIBLE COUPLINGS
FOR DIRECT-CONNECTED MACHINES

All Metal Any Size Any Power
Any Service

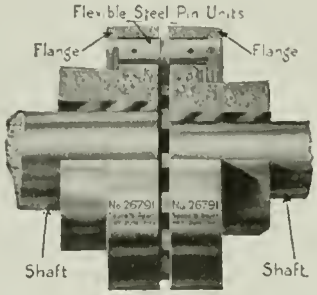
"To make good machines last longer"

New Fractional H. P. Type

Small, inexpensive sizes only for small motor driven generators, fans, pumps, sewing machines, and for magneto and pump drives, etc.

Light Duty Type (1921) and Heavy Pattern Type (1912)

In capacities from 2/3 H.P. per 100 R.P.M. and shafts ½" dia. up to 3200 H.P. per 100 R.P.M. and shafts up to 13½" diameter.



For all usual direct connected drives where a flexible coupling should be used to provide for the errors in shaft alignment. Each "FRANCKE" also provides an easy means to line up the connected shafts, it cushions load shocks and vibrations, and it acts as a safety device in case excessive misalignment results from an operating accident.

Double, Floating Ring Type (1914)

Recommended for continuous process drives and where excessive misalignment is expected.

Has been built and used successfully on drives in capacities up to 8000 H.P. per 100 R.P.M. and for shafts up to 18⅞" diameter.

Marine Type (1912)

Constructed with a center bolt to transmit the thrust and reverse pull from the propeller shaft. Small sizes.

New High Speed Type

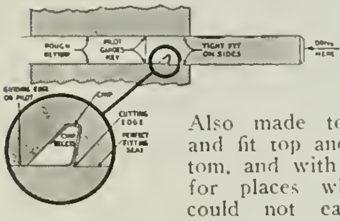
Now being developed and offered for high speed motor and turbine driven herringbone gear units, etc.

A properly sized all-metal "FRANCKE" lasts longer and provides proper flexibility. Is your name on our mailing list?

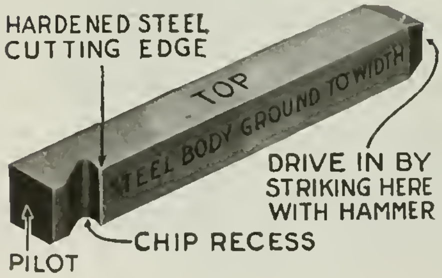
New

The self-fitting key which cuts the cost of all hand-fitting

Drive a "Keytite" into the ordinary keyseat and leave it there. The cutting edge sizes the rough keyways to make a finished fit. Does not require a skilled mechanic and always insures a correct fit.



Also made to cut and fit top and bottom, and with heads for places where it could not easily be drifted out.

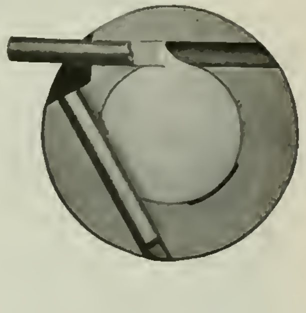

HARDENED STEEL CUTTING EDGE
TOP
STEEL BODY GROUND TO WIDTH
DRIVE IN BY STRIKING HERE WITH HAMMER
CHIP RECESS
PILOT

KEYTITE
SELF-FITTING KEYS
EVERY KEY SIZES AND FITS ITS OWN SEAT

PINTITE
RIGID COUPLINGS
FOR LINE SHAFTING

"Pinned Tight"—These two words tell the grip of a PINTITE on the shafts which it connects—a grip that no service chain can break.

Install with the shaft ends together within the bore of the sleeve and simply drive the cup-ended pins home with a hammer.



Each cup-ended, hardened steel pin cuts its own seat in the shaft—a keyway deep enough to hold inflexibly but not deep enough to weaken the shaft.

To remove—Drive pins out backwards, using a round end drift. Turn coupling on shafts, then drive it off shafts and use again in a new or in the same location.

Any size up to 4 7/16".

Since 1917

SMITH & SERRELL
Coupling Specialists Since 1912.
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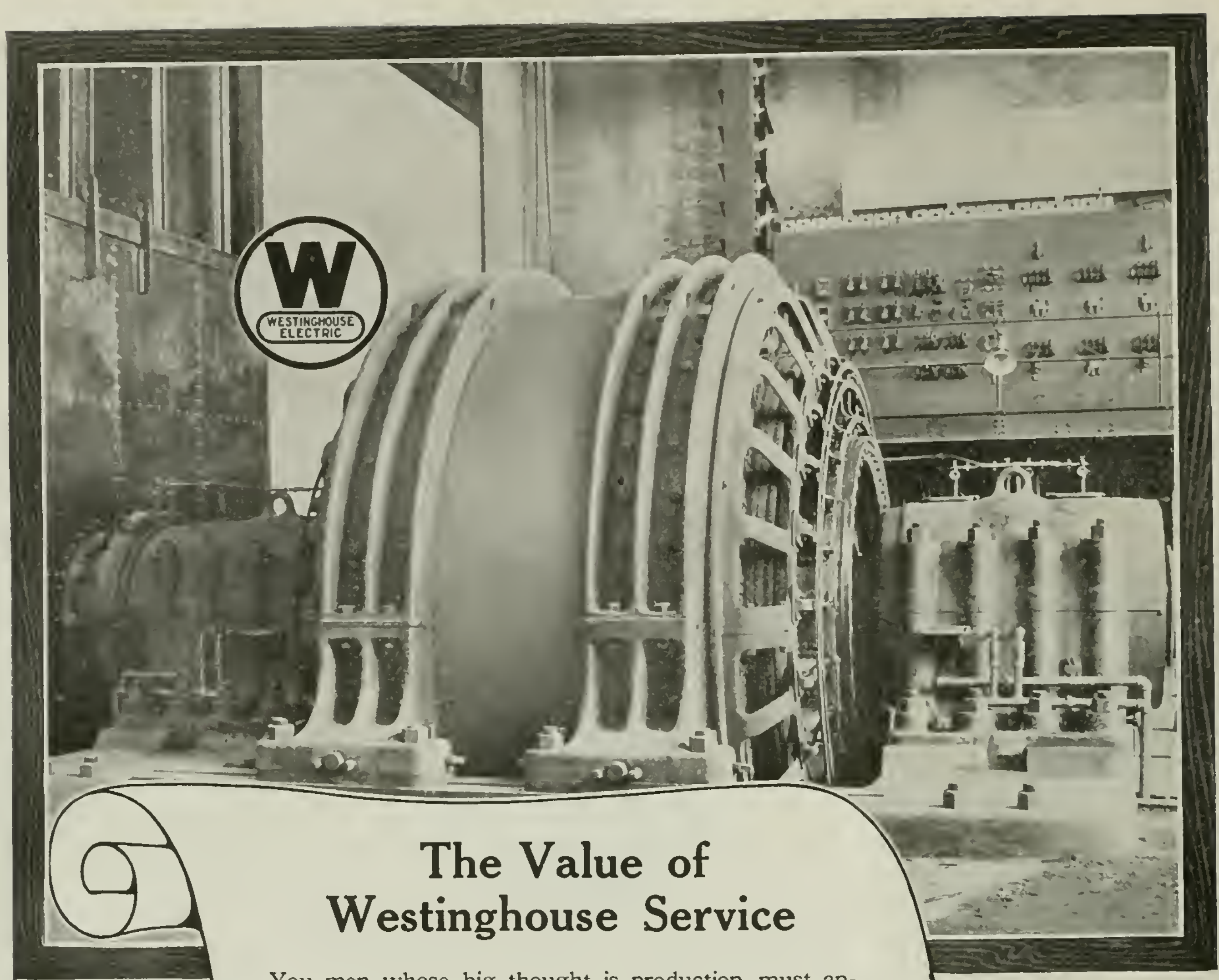

Reversing Motor Driving 44" Reversing Blooming Mill.
Bethlehem Steel Co., Steelton, Pa.

The Value of Westinghouse Service

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The Blast Furnace and Steel Plant

Vol. X PITTSBURGH, PA., DECEMBER, 1922 No 12

Mills Built for Rolling Nickel and Monel

Brief Description of the Refining Process and of the New Rolling Mills at Huntington, W. Va.—Physical Properties of Monel Metal.

THE engineering profession, and the steel industry both owe a debt of untold proportions to nickel. In its many forms, pure and in alloys, it has made simple, many problems otherwise difficult or impossible of solution. Today, nickel is a definite necessity.

So universal has its use become that an entire industry has developed to keep pace with the demands for its production. As investigation after investiga-

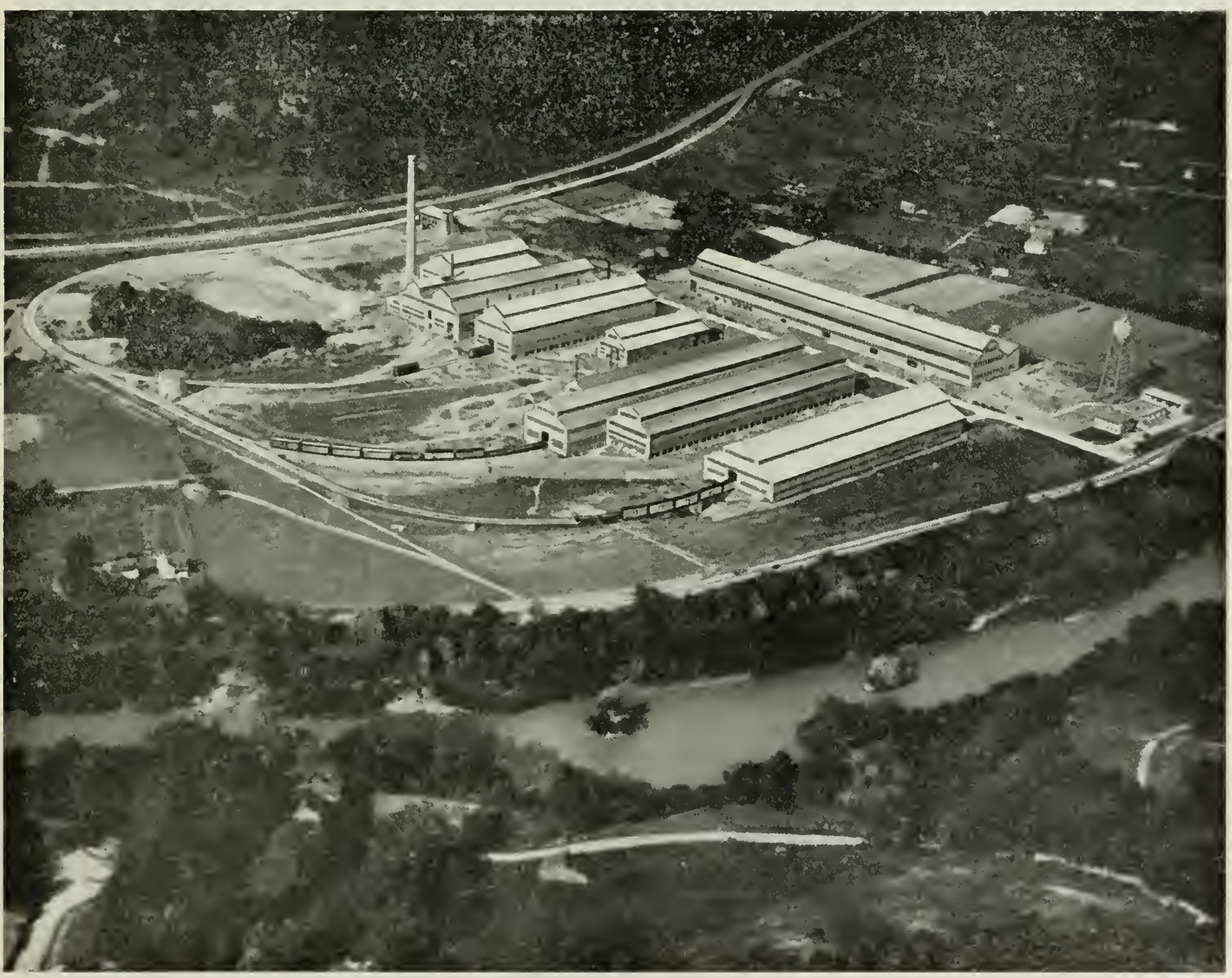

Fig. 1—An aeroplane view of the new rolling mill plant. In the foreground is shown a bend of the Guyandotte River, tributary to the Ohio. The group of parallel buildings in the main foreground constitute the calcining department in which the monel matter is converted into metal. At right angles to the calcining buildings is shown the rolling mill building. The main line of the Chesapeake & Ohio Railroad is shown in the background.

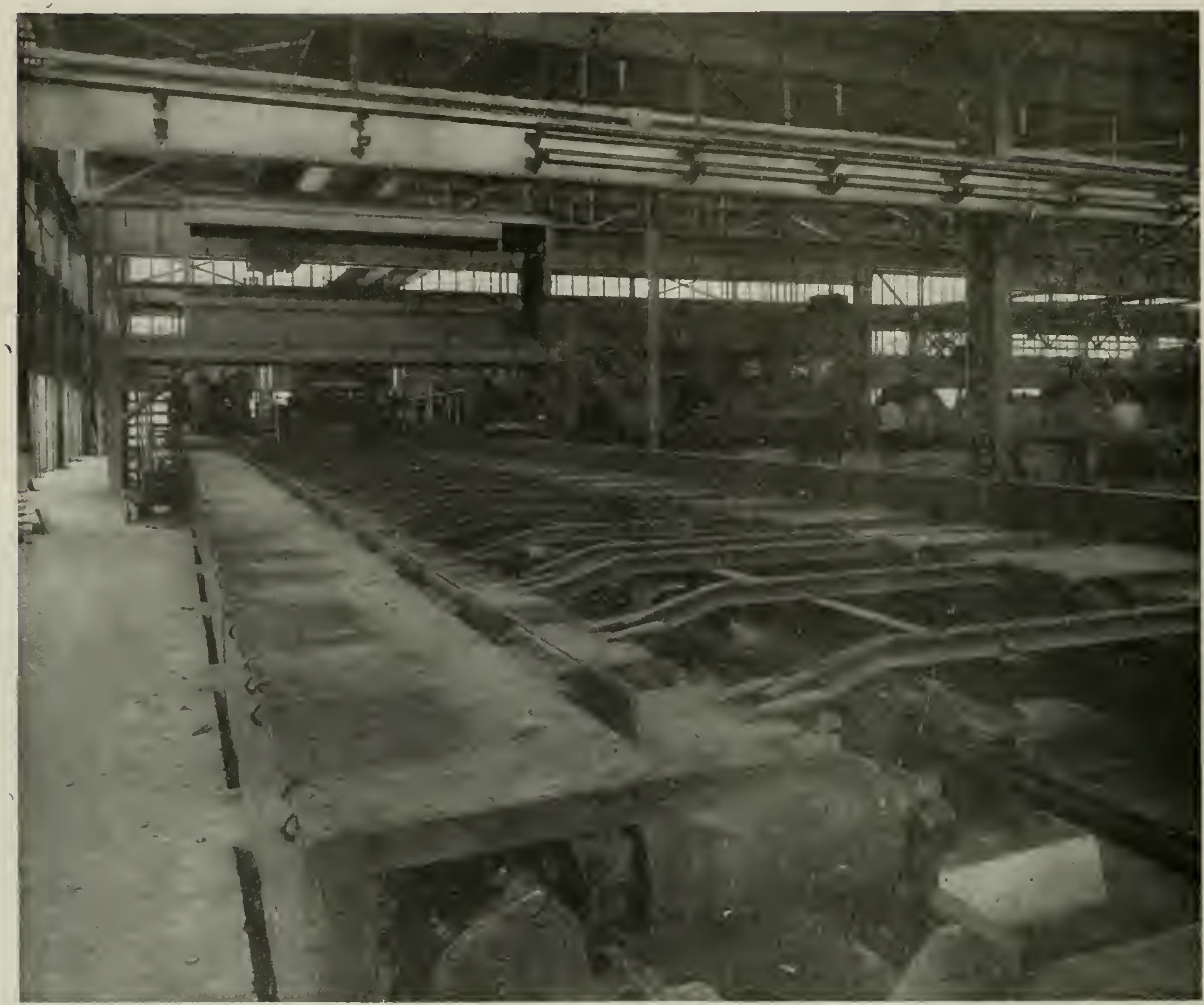

Fig. 2—The 24-in. merchant mill in which the billets of monel metal are reduced to sheet bars. The entire mill is controlled electrically by one man standing in the pulpit shown in the background. The heated billets are delivered by an electric charging machine from gas-fired furnaces which do not appear in the photograph. In the background at the right is shown the special electrical control for both the merchant mill and the rod mill, part of which appears in the right-hand background of the photograph.

tion has disclosed new and broader applications for nickel and its combinations particularly monel metal, greater and greater facilities have arisen for its production and manufacture. The latest chapter in the romance, begun in 1884, when the copper nickel deposit near Sudbury, Ontario, was discovered in the construction of the Canadian Pacific Railroad through that province, opens with the completion and actual operation of the group of rolling mills at Huntington, West Virginia. These mills, completely modern, the last word in rolling mill practice, complete the sequence of operations by which the International Nickel Company, from the ore in the mine to the finished sheet or rod or wire, are enabled to deliver the product made entirely under their own supervision, and in their own plants.

Both malleable nickel and monel metal are now under production. Many difficulties had been encountered, for rolling steel is one thing and rolling nickel or monel is another; what seemed an entirely similar operation, differs widely in important details, and men trained in steel mill practice had to re-adapt their experience to monel practice. That can best be done in a plant designed for the purpose, as experience has shown.

The plant is located at Huntington, W. Va. This site was selected after a very careful investigation of the many advantages claimed for various industrial centers. Huntington combines the many basic factors, which experience has shown are necessary for monel and nickel sheet production. Intelligent labor has provided excellent home environment Adequate electric power is supplied by the Virginia Power Company, over high tension transmission lines from its main generating station about 60 miles distant. Contiguous high-quality coal and natural gas, both essential to the heavy heating requirements throughout the processes are furnished over unexcelled transportation facilities, offered by the Ohio River by water, and the main lines of the Chesapeake & Ohio and the Baltimore & Ohio Railroads, while natural gas is adequately supplied from local fields.

Fig. 1 shows an aeroplane view of the plant and its location. Some 80 acres, about 3½ miles south of the city, directly adjoining the C. & O. main line tracks, are occupied. The mills are really divided into two parts. The calcining department is located in the foreground in which the monel or nickel matte is converted into metal, and the sheet mill at right angles to it, where are located the rolling mills, the heating furnaces, annealing furnaces, shears, etc.

Monel metal and nickel are so often spoken of in such general terms that a brief glance at the complete process, or chain of processes may be interesting. The ore, stop-mined at present depths of approximately 1,200 ft., consists of pyrhotite, with chalcopyrite and pentlandite, together with a basic gangue material. These sulphide ores are roasted to reduce the sulphur to a working average, then smelted in a blast furnace to a matte containing approximately 24 per cent nickel, plus copper, 45 per cent iron and the balance sulphur. This matte is then blown in a converter, similar to the familiar Bessemer steel operation, to a matte containing essentially nickel, copper and sulphur, which is ready for refining.

This Bessemer matte, which carries approximately 55 per cent nickel and 24 per cent copper is refined by the Orford process, which is the oldest process for the separation of copper and nickel The Bessemer matte is melted with salt cake, or niter cake, together with coke, in the blast furnace. The sodium sulphide formed by the reduction of the sodium sulphate by the coke, together with the copper sulphide, forms a matte of low specific gravity. The product of the blast furnace is allowed to cool in pots, in which a separation occurs, the upper portion or "tops" containing the greater part of the copper sulphide together with the sodium sulphide, the lower portion or "bottoms" containing the greater part of the nickel sulphide. The "tops" and "bottoms" are readily split apart when cold. Several treatments are required to effect a sufficiently complete separation. The "tops" go to the copper cupola and converter, where they are blown to blister copper. The "bottoms," consisting, essentially, of nickel sulphide or matte, are roasted and leached alternately until they have been completely changed to nickel oxide. This is reduced with charcoal in crucibles or reverberatory furnaces to metallic nickel at a temperature above its melting point, so that the resulting product may be cast into pigs. The waste heat from the latter battery of furnaces is utilized to fire large boilers which will supply the ordinary steam requirements of the four large hammers. As a standby for the latter, natural gas fired boilers are installed in the hammer shop.

From the reverberatory furnaces the metal in the form of pigs goes to the electric furnaces where it is remelted and cast in the form of ingots, or blocks, or poured into water to form shot. Electrolytic nickel is also produced by casting this reduced metal at once into anodes and obtaining pure nickel cathodes from them by electrolysis with an electrolyte of nickel sulphate.

The equipment in this department consists of one

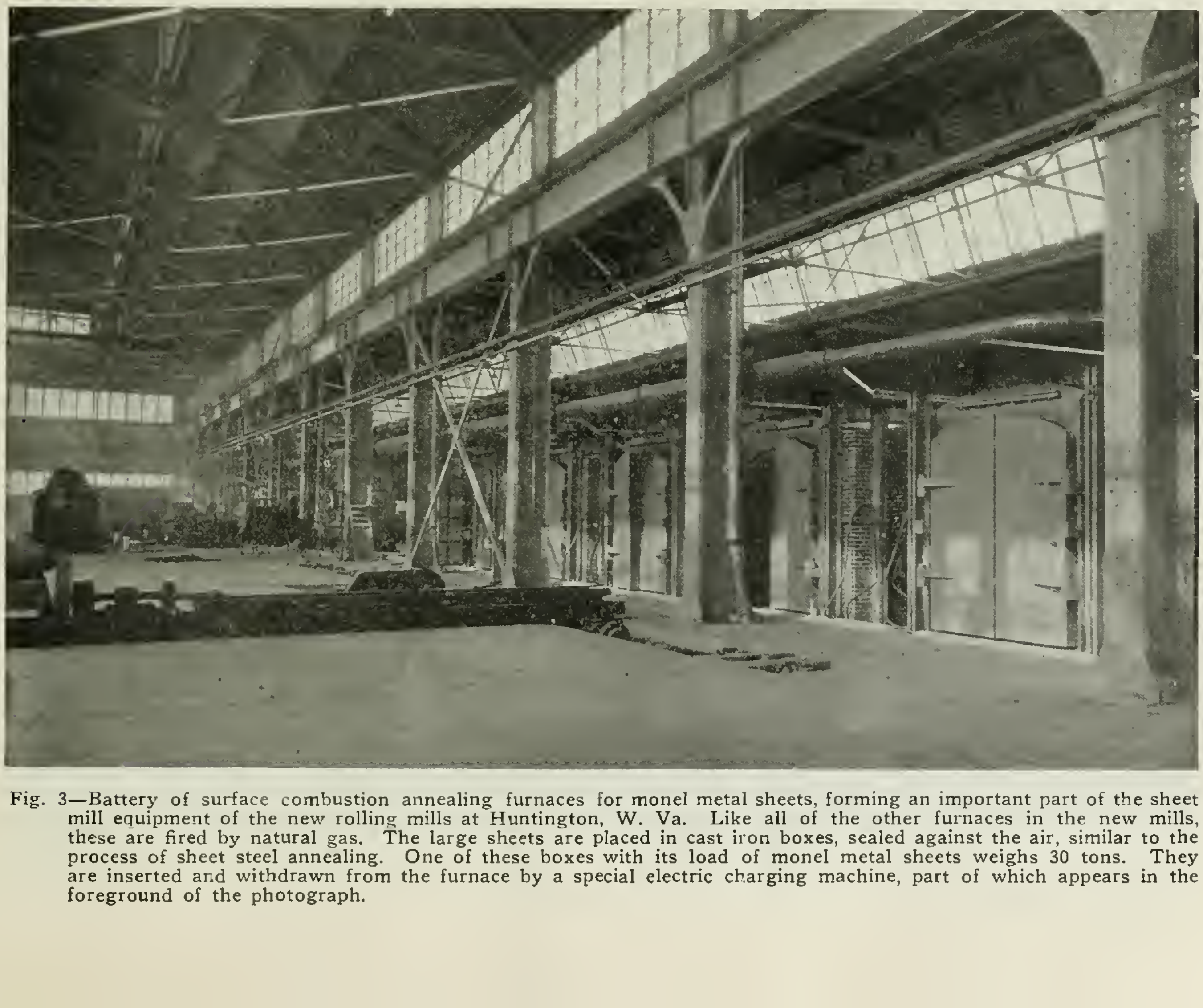

Fig. 3—Battery of surface combustion annealing furnaces for monel metal sheets, forming an important part of the sheet mill equipment of the new rolling mills at Huntington, W. Va. Like all of the other furnaces in the new mills, these are fired by natural gas. The large sheets are placed in cast iron boxes, sealed against the air, similar to the process of sheet steel annealing. One of these boxes with its load of monel metal sheets weighs 30 tons. They are inserted and withdrawn from the furnace by a special electric charging machine, part of which appears in the foreground of the photograph.

3-ton Moore electric furnace and one 7-ton Heroult electric furnace, so that its present capacity is in excess of that of the remaining departments as at present equipped, while provision has also been made for the installation of further electric furnace units as required. So far as refining in electric furnaces and ingot casting are concerned, the handling of monel metal in this department does not differ materially from the usual steel mill practice.

Number of Special Operations.

In the next step in its reduction to commercial form, a number of operations are involved that are entirely lacking in steel processing. In the case of steel, the ingot goes directly to the soaking pit, the time required for this part of the process is short and involves little additional expense as compared with the time and processes through which the monel metal ingots must go after leaving the ingot mold and before they can be delivered to the rolling mill. Steel is a metal very susceptible to oxidation and surface defects on the ingots are automatically removed by the heating and rolling processes in which the oxidation scales off, leaving clean metal. Monel metal, on the other hand, is highly resistant to oxidation so that it is necessary to remove the outer skin of the ingot completely with its accompanying surface defects before proceeding to the heating and rolling.

Consisting chiefly of nickel and copper as it does, the metallurgy of monel metal is radically different from that of steel so that its successful production is naturally a highly specialized undertaking which can only be carried out by skilled men experienced in its handling. In the course of manufacture up to this point, certain defects, or oxides, are allowed to remain in the ingot. These oxides do not combine chemically with the metal but appear on or close to the surface of the ingot as physical defects. These defects, however, must be removed before the metal can undergo any further processes.

The ingots are accordingly taken to milling machines where a heavy cut is taken off each side. As an extra precaution to insure satisfactory quality the milled ingots are examined and any defects remaining are chipped out with pneumatic hammers.

Equipment Provided on a Liberal Scale.

After the chipping processes the ingots go back to another battery of furnaces in the hammer department, where they are cogged down to bloom size. The steam hammers employed in this department range from eight ton capacity down to 1,500 pounds, so that ample provision is at hand for the making of special forgings of monel metal or nickel, in addition to the usual production of monel metal blooms for the rolling mill itself.

After heating in the battery of furnaces in the rolling mill department itself, these billets go to the 24-inch merchant mill for conversion into sheet bars, or to the rod mill. So far as the actual handling of monel metal is concerned, either in the merchant or the rod mill, or in its subsequent reduction in the sheet mills in another unit, there is no apparent difference between its production and that of steel. With

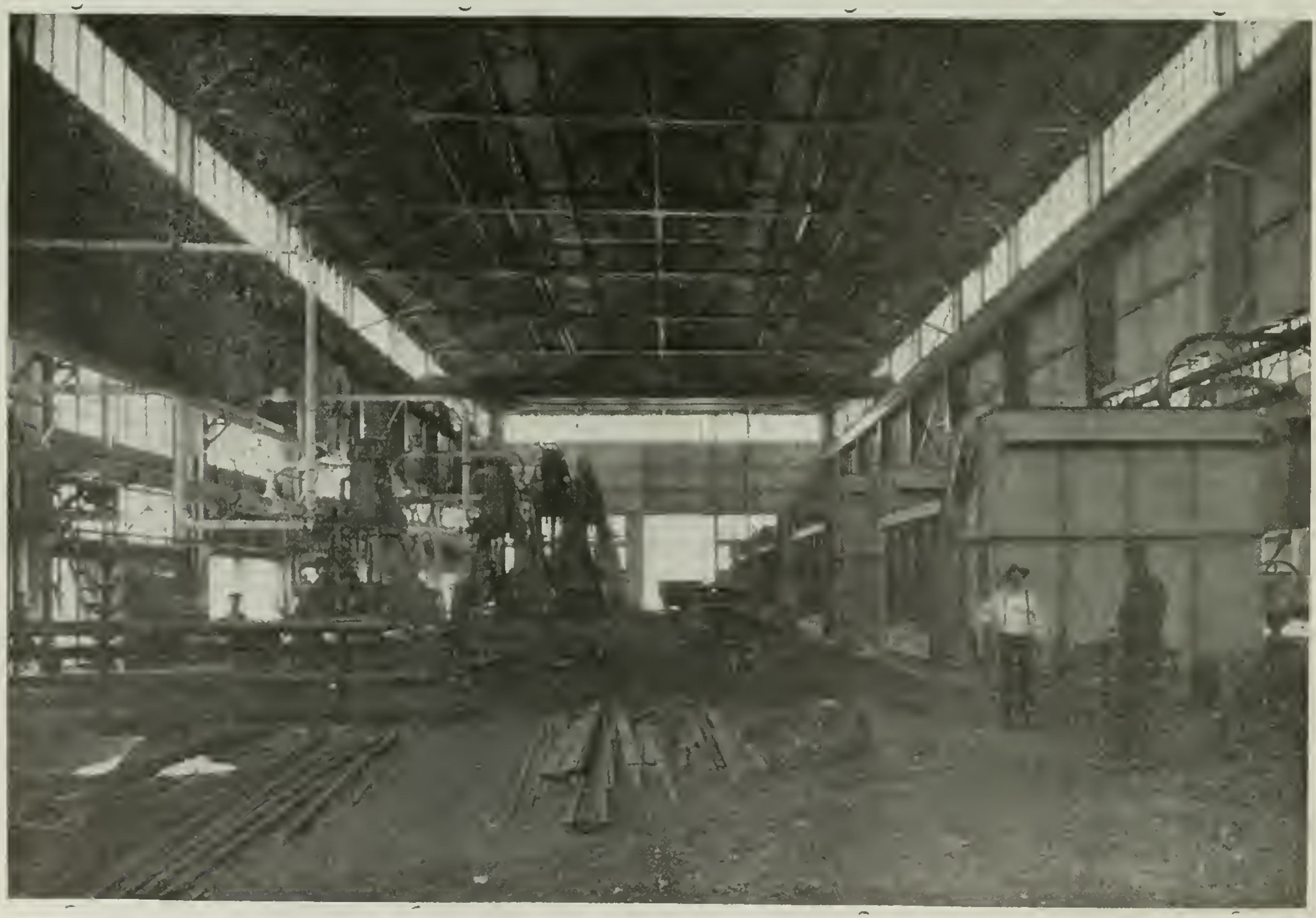

Fig. 4—View of the hammer shop and its batteries of Stevens regenerative gas fired furnaces. The four hammers range from 1500 pounds capacity in the foreground to the 8-ton hammer at the end of the line. In the latter the monel metal ingots are cogged or reduced from ingots to blooms.

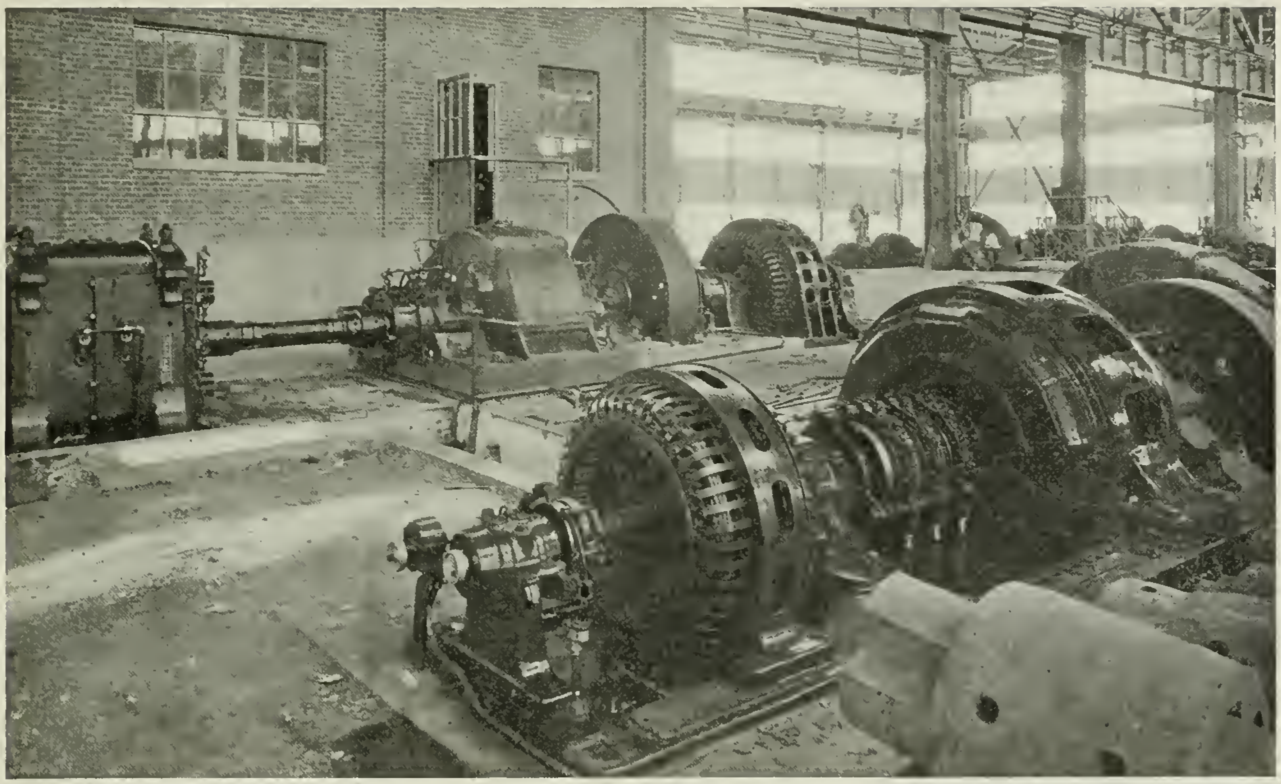

Fig. 5—The control house for the merchant and the rod mills, showing in the background part of the electric drive for the 24-in. merchant mill and in the foreground the special form of drive designed by General Electric and Westinghouse engineers for the rod mill. A rod mill consists of a series of units tapering down from the largest to the smallest and the speed of each unit must vary in accordance to the size of the rod it rolls.

a metal consisting chiefly of nickel and copper the greatest problems are naturally involved in the heating of it and this is equally true in every step of the process from the calcining furnace to the final annealing processes.

Some Features of the Sheet Mill.

The bars from the merchant mill go to the sheet mill which is a most complete, specially designed plant for the production of monel metal sheets and which will do more to overcome the difficulties in providing an adequate supply of monel metal sheets than has been possible up to this time, since a very large part of the production difficulties have had to do with the rolling of sheets. In this department, as is also true of all of the others, while equipment has already been installed with a capacity far in excess of the actual requirements, ample provision has also been allowed for expansion and the installation of additional units whenever required, so that with an ample supply of high grade metal direct from its own furnaces and rolling mills, the International Nickel Company will be in a position to maintain adequate stock of all sizes and gauges of monel metal sheets at the warehouses of various distributors in different parts of the country from now on.

Grinding machinery has been installed to make it possible to deliver monel metal and nickel sheets ground to a good surface so that a wide range of articles may be produced from these sheets with the minimum amount of buffing in the finished form.

So far as a detailed description of the buildings and equipment is concerned, probably a very much better idea of this can be obtained from the photographs and will likewise be found considerably more interesting. It will be noted throughout that electric unit drive is employed on every machine and that the controls for the large rolling mill units are protected by special compartments, or houses, raised several feet above the floors or rolling mill itself. Numerous advances over current rolling mill practice have been incorporated in these control units, this being true in particular of one control of the rod mill in which the speed varies from 450 to 100 rpm.

The series of units comprising the rod mill is driven by a 400-hp., a.c. motor and a smaller d.c. motor, both of which work in conjunction with a highly specialized control system to give the great range of speed required. The necessary controls are installed in a small brick house as will be noted in several of the accompanying photographs. While these pictures show the mills in a more or less unfinished condition before production operations had actually been undertaken, they serve to give a very good idea of its size, completeness and ultimate capacity. It will be noted that in every department ample provision has been made for expansion by the addition of extra units, although as stated previously, with the equipment already installed and now in operation, the capacity far exceeds the present requirements. While the demand has showed a very marked increase since the beginning of the year, the capacity of the new mills at Huntington will be sufficient to meet all calls for sheets and rods as well as forging and special work, and at the same time permit of local stock in the warehouses of distributors.

Completely Equipped Laboratories.

With a natural alloy of such unusual and distinctive physical properties as monel metal, it goes with-

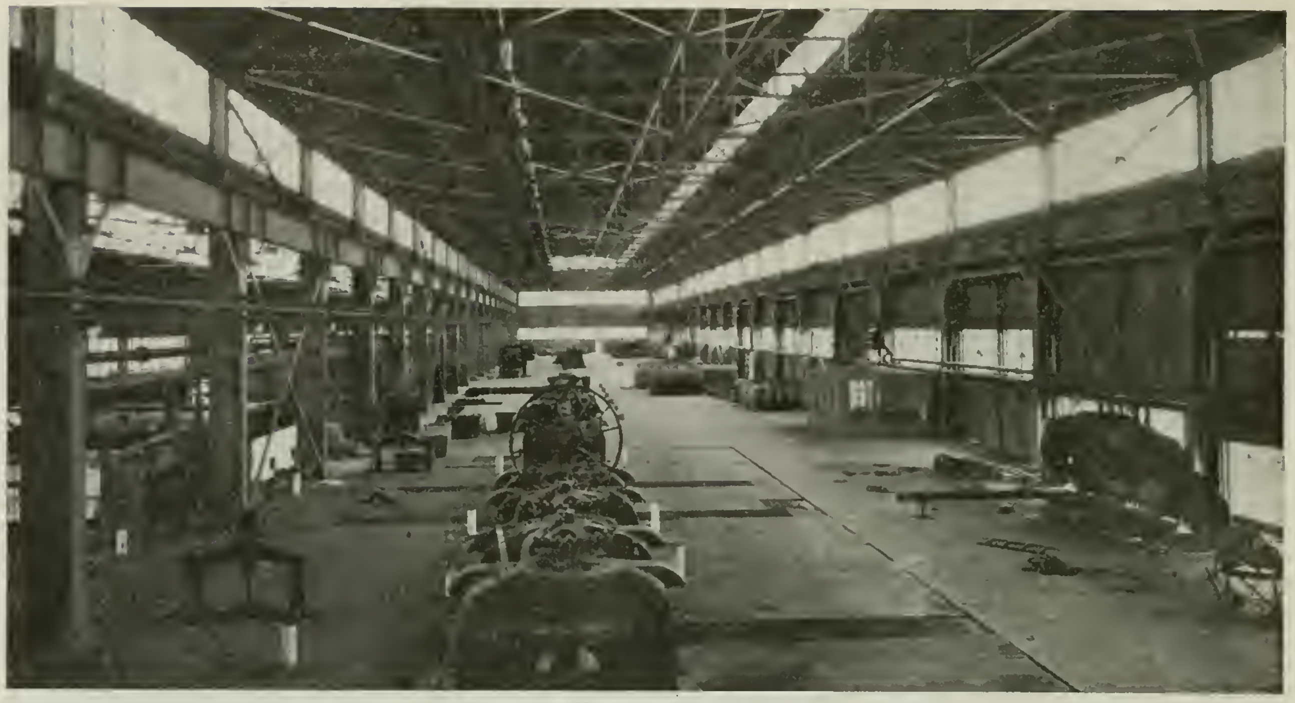

Fig. 6—View of the sheet mill looking toward the north end. The battery of heating furnaces for the sheet bars is located at the left and does not appear in the photograph, while the annealing furnaces shown in a previous photograph are further back on the same side of the building. The second unit of the sheet mill appears in the background, but it is difficult to give any idea of the extent of the equipment of a single building of this size in a photograph.

out saying that the most important units at the new mills are the laboratories. They are permanently housed in a building specially planned for this purpose and completely equipped for carrying out chemical and physical tests of every nature. Both in the reduction of the matte to monel metal in a great number of commercial forms and in its application in a wide variety of manufacturing processes, problems are constantly arising. The staff of the laboratories at the Huntington mills is at the service of manufacturers in solving these problems, as is also that of the research department of the International Nickel Company. In the course of more than 15 years' work of this nature, a vast amount of data has been accumulated so that frequently what appears to be a difficult problem to a manufacturer is already a matter of actual experience. The benefits of this experience are at your disposal.

Fig. 7—Completely equipped chemical and physical laboratories which form a very important part of the new rolling mills of the International Nickel Company at Huntington, W. Va.

Range of Products

Both monel metal and nickel will be produced at the new Huntington mills in the form of rods from 7/32-in. up to 12-in. round, square or hexagonal and in sheets from .018 to ¼-in. These sheets will be rolled in all sizes commonly supplied in sheet steel Special forgings in either monel metal or nickel can also be furnished.

Personnel of the Organization.

For years the Nickel Company has been gathering together a technical operating organization capable of visualizing the magnitude and importance of the many problems and possibilities of this specialized industry. The steel industry furnished many. Ambrose Monel, whose name indicates the conception that nickel and copper would be refined (without separation) into an alloy of tremendous value, went from Homestead Steel as did Bostwick and others.

Today the organization headed by Mr. Robert C. Stanley, a veteran in the company, of whom it is said, no other man ever held a like number of positions from the bottom up, is keenly alert to every development that definite research into each industrial avenue brings to light.

The Research Departments are under the direction of Mr. A. J. Wadhams, assisted by Dr. Paul D. Merica, formerly of the U. S. Bureau of Standards, working in conjunction with Dr. J. F. Thompson, head of the Technical Department. Dr. Thompson has devoted many years to the study of nickel alloys and his papers before engineering societies and published articles on kindred subjects are well known. In addition, the Sales and Publicity Departments, headed by Mr. J. F. McNamara, with his corps of investigating specialists, are constantly solving the problems of manufactures of innumerable products, where the special virtue of nickel and monel offer an application.

Backed by such an organization, it is not surprising that Mr. A. S. Shoffstall, General Manager of the Huntintgon mills, and Mr. H. M. Brown, the Mechanical Engineer, look forward to uninterrupted production records, that will fully keep pace with the anticipated revival of the steel and metal working industries.

The physical properties of monel may be of reference value.

PHYSICAL PROPERTIES OF MONEL METAL

Melting Point	1360° C. (2480° F.)
Specific Gravity (Cast)	8.87
Weight Per Cu. In. (Cast)	0.320 Lbs.
Weight Per Cu. In. (Rolled)	0.323 Lbs.

Coefficient of Expansion:

(25° C—100° C)	0.000014 Per 1° C.
(25° C—300° C)	0.000015 Per 1° C.
(300° C—600° C)	0.000017 Per 1° C.
Electrical Resistivity	256 Ohms Per Mil-Ft. 42 Microhms Per Cm.
(Temp. Coefficient	0.0011 Per 1° F.)
Electrical Conductivity	4% (Copper 100%)
Optical Reflectivity	60% of Silver
Heat Conductivity	1/15 that of Copper
Shrinkage	¼ Inch per Foot
Hardness Cast Material	20-23 (Shore Scleroscope)

Hardness Hot Rolled Rods:
27 (Average Shore Scleroscope).

Hardness (Brinell, 3,000 Kg.).

Hot Rolled Rods	162
Cold Drawn Rods	160-245
Castings	115
Modulus of Elasticity (Young's)	25,000,000

Thermal Conductivity:
0.06 Calories Per 1° C. Per Second Per Cm³.
True Specific Heat:
0.109 Calories Per Gram Per 1° C.
Magnetic Induction for H = 100 .... 1,500 Gausses

Energy Absorption:

Izod Test	115
Charpy Test	160
Toughness	1580
Heat Treated Carbon Steel (S. A. E. 1045)	920

Torsional Tests on Rods (Average).

Shearing Stress—Lbs. Per Sq. In. on Remotest Fibres:

At Elastic Limit	31,796 Lbs. Per Sq. In.
At Ultimate Load	79,053 Lbs. Per Sq. In.

Tensile Tests on Castings:

Yield Point	37,093 Lbs. Per Sq. In.
Tensile Strength	72,281 Lbs. Per Sq. In.
Elongation in 2 Inches	34%
Reduction of Area	32%

Tensile Tests on Sheets:

Yield Point	25,000 Lbs. Per Sq. In.
Tensile Strength	65,000 Lbs. Per Sq. In.
Elongation in 2 Inches	35%

Tensile Tests on Hot Rolled Rods:

Rounds and Squares	Yield Point Lbs. Sq. In.	Ult. Ten. Str. Lbs. Sq. In.	Elong'n in 2 In.
Up to 1"	63,126	94.562	40%
1 1/16" to 1 11/16" Inc.	61,963	93,104	39%
1¾" to 2 7/16" Inc.	50,115	87,678	42%
2½" to 3½" Inc.	43,805	85,282	44%
Over 3½"	47,335	84,763	43%
Rectangles	56,353	85,562	42%
Hexagons	60,736	87,781	40%

Proportional Limit .... 35,000 to 45,000 Lbs. Per Sq. In.

Compression Tests on Hot Rolled Rods:

Elastic Limit	45,000 to 50,000 Lbs. Per Sq. In.
Yield Point	67,000 Lbs. Per Sq. In.

The tensile strength of Monel Metal wire varies from 80,000 pounds per square inch to 150,000 pounds per square inch, depending on the temper.

Shear Tests on Hot Rolled Monel Metal Rods 1⅛" Round:

Diam. of Test Piece	Single Shear Stress Lbs. Per Sq. In.	Double Shear Stress Lbs. Per Sq. In.
1"	61,092	127,200
¾"	49,883	103,267
	1" Round	
1"	55,163	115,500
¾"	44,806	90,163

The general properties of pure nickel parallel monel very closely, differing slightly under special conditions, each has its particular advantages for specific use.

THE BUDGET

Much has been written recently on the mechanics and machinery of the budget in private enterprise, but little has been said about the spirit behind the budget.

"It is this spirit behind the budget," says E. W. McCullough, manager of the Fabricated Production Department of the Chamber of Commerce of the United States, "which, in the last analysis, will determine whether the forms and procedure of budgetary control shall have meaning and usefulness, or whether they shall mean but another addition to the administrative red tape now cluttering business.

Mr. McCullough deals with this phase of the subject in a bulletin which his department has just issued under the title, "Budgeting for Business Control."

"The first point in a reasonable financial program," says Mr. McCullough, "is to aim for that amount of business within one's resources to handle which will give a fair return and which is founded upon a conservative view of the real demands of the consumer.

"The second is to strive to make the most of capital resources; establishing a production system; by refraining from plunging into expenditure for new plants and equipment where the old will serve the purpose; by placing collections on a reasonably prompt basis; by having purchases in line with production and sales programs and by refusing to act as a free warehouseman.

"The third is to regulate current borrowings in such a way that they will be well under control. As the business of a firm expands, the lag between the order and payment date increases, bringing with it a growing need for banking accomodations. These banking requirements are usually granted, for the increase of business is a warrant of the success of the enterprise. New loans are made and old ones are renewed and extended, until almost insidiously grows the conviction on the part of the manufacturer that the short term accomodations are a fixed contribution to the capital of his business, and he acts and works upon this assumption Inevitably, the day comes when the bank finds itself pressed for funds and, in turn, calls on the manufacturer for payment, and since such a demand usually comes at a time of business depression, the manufacturer finds himself unable to liquidate. Then very likely reorganization ensues, resulting at best in the short term funds becoming, upon onerous terms, a part of the funded or long term obligations.

"For all lines, seasonal and non-seasonal, it should be clearly realized that short time obligations are not a permanent contribution to capital and that manufacturers should hold themselves in readiness to liquidate accounts receivable over current indebtedness. Short term obligations should bear a definite relationship to the capital."

The Manufacture of Fine Forging Steels

Electric Furnace Practice, Casting Methods, Raw Materials Used. Heat Logs for Carbon, Chromium and Nickel Chromium Steels.

By LARRY J. BARTON*

WAR time conditions of hasty production are a thing of the long gone past, the period of depression is gradually going, and American manufacturers are gradually awakening to the fact that if they are to meet low priced foreign competition it must be upon the greater merit of their higher priced product. Production is going ahead by leaps and bounds and again the call is coming forth for high grade forging steels. The writer offers the following treatise for the possible help manufacturers may obtain, the results and practice given being those following experiments and tests covering an extensive period, and accepted over others as superior, both from the standpoint of quality and their commercial costs. For ordinary grades of forging stock the cost of electric melting and refining is too high to compete with the open hearth furnace, in which very fine steel can be made. In such industries as the automotive—covering automobiles, aeroplanes and tractors; the railroad, both steam power and electric driven; and the general machine and equipment, covering all machines using reciprocating or fast moving parts, the trend is towards lighter weight forgings. In order to sufficiently meet the ever increasing strength and ductility specifications a superior grade of steel must be used. Then, when it is considered that the sections are always becoming smaller, the highest quality of steel is needed to meet the demand.

This has encouraged the electric furnace manufacturers of high quality steels, for it is only by this method of operation that many difficult specifications can be adequately satisfied. Heat treating and research have developed many properties of the alloy steels which were unknown a few years ago, giving rise to an increased market and demand for this class of work. Alloy steel castings in the heat treated condition are rapidly replacing forgings in many cases. This paper covers only the making of the ingot and its further operations, but the same furnace practice is applicable to making alloy steel castings with slight modifications such as any metallurgist will readily recognize.

While it is appreciated that very fine steels have been, and are still being made in the acid electric furnace, I do not believe they can compete with the basic electric on a highest quality basis. There are so many small points where the basic process shows its superiority that it is needless to mention them, this subject having been thoroughly covered by much more able men than the writer. The following processes will, therefore, be considered as covering basic operation. No class of electric furnace is mentioned, as all, when properly operated, will thoroughly meet conditions when considered from the strict metallurgical view. The same follows of ladles, refractories, treating equipment, etc.

Proper Care of Furnace to Obtain Maximum Results.

The Hearth—One of the greatest troubles in obtaining a very high grade and uniform product consistently is with the furnace bottom. Alloy steels require a longer time in the furnace than any other class of metal, throwing a greater period of strain onto the hearth. In addition, some are more or less severe on the bottom, due to their erosive action, in addition to their higher melting points above that of the plain carbon alloys. It is indeed discouraging to the melter to find that at about the time he is finishing his heat the bottom starts rising in patches, often requiring instantaneous tapping and either scrapping the heat or placing into a cheaper grade of work. This too, results in a higher cost of manufacture, and often through over zeal on the melter's part results in an inferor steel poured into a product requiring the highest grade metal obtainable, a point which works to the direct disadvantage of the shop concerned. With the idea of eliminating this point I strongly advocate the use of a hearth made by burning in the refractory bit by bit, instead of ramming and then burning. I also advocate using the best grade of dead burned magnesite obtainable for the hearth proper.

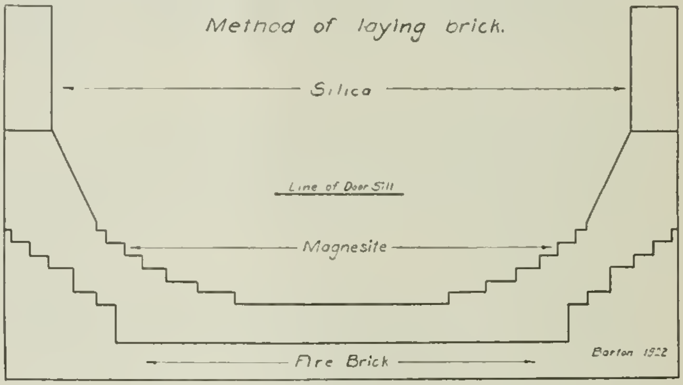

Fig. 1—Indicating the manner in which brick are laid in the furnace shell.

Making Bottom—The furnace shell is bricked up as per Fig. 1. Short pieces of electrode are then arranged on the bottom as shown in Figs. 2, 3, and 4. Either way is optional, depending on the size of the furnace (number of door openings), the electrodes, whether carbon or graphite, and the depth of hearth desired. Personally I like Fig. 4 better than the others as it offers better accessibility to the front of the furnace, and gives a strong support to the electrodes. Great care must be used in setting up these electrodes on bricks as a breaking apart will seriously interfere with the proper completion of this very important operation.

Basic open hearth, or blast furnace, slag in the finely ground conditions now dusted over the bottom bricks, until all cracks are filled. This should be carefully done as it is essential to thoroughly fill any small openings with this material. A small amount is then dusted all over the bottom. The furnace is now ready to be dried out, and this operation should not be stinted. A very low gas or oil flame is inserted through one of the doors and the furnace sealed, only allowing enough air to enter to support combustion. A large amount here depends upon the judgment of the melter as to how long this flame should burn before being raised. I recommend to burn several hours at the least until all surface moisture is driven from the furnace. The flame can now be progressively raised until in about six or eight hours the flame is burning full. The point of the flame should now be so regulated that its direct heat is thrown towards the center of the hearth. This is kept on until the furnace ceases emitting any steam from around the vent holes in the bottom and sides, and may take 24 hours or more depending upon how moist the refractories were. I have ordinarily found that about 12 to 15 hours is ample for this, but you must remember the old adage "better be safe than sorry." By this time the furnace walls will be a good bright red, and all preliminary expansion will have been taken up by both the roof brick and the others. Any slight spalling of either the magnesite or silica brick can now be raked from the furnace, and the actual burning begins.

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*Consulting Metallurgical Engr., Los Angeles, Calif.

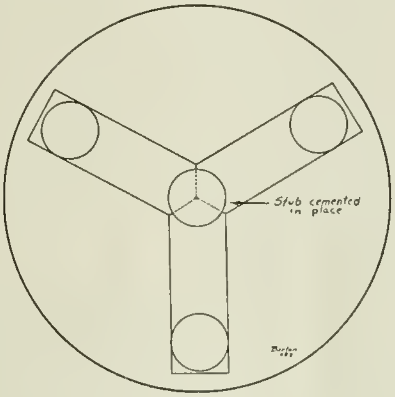


Fig.2— Showing typical position of electrodes in furnace bottom.

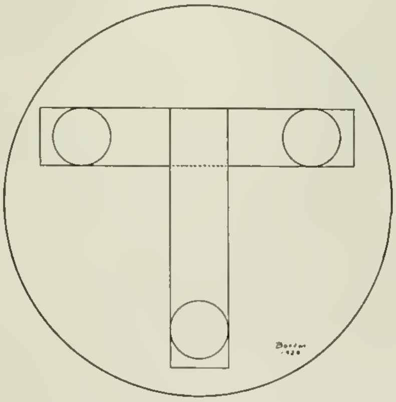


Fig. 3—A second disposition of electrodes in furnace bottom.

The furnace electrodes are lowered until an arc is made with the hearth set-up. This is a point which should be very carefully watched for if any electrode is lowered too much there is a great possibility of it forcing the bottom electrodes out of place causing no end of serious trouble. As all the electrodes are now at a good red heat the arc will hold steady, and the current can be thrown over to the automatic regulators. This should be held at the lowest possible figure for about an hour, and gradually raised over a period of at least four or five hours until the ground slag on the hearth is in a molten condition and running freely. The temperature should now be held at a point where the side walls are glistening, but care should be taken not to allow the silica brick to run. Magnesite, ground to about the size of wheat, can now be dusted lightly all around, and the doors again closed. Further additions of this character can be made about every half hour. tests being taken before each addition.

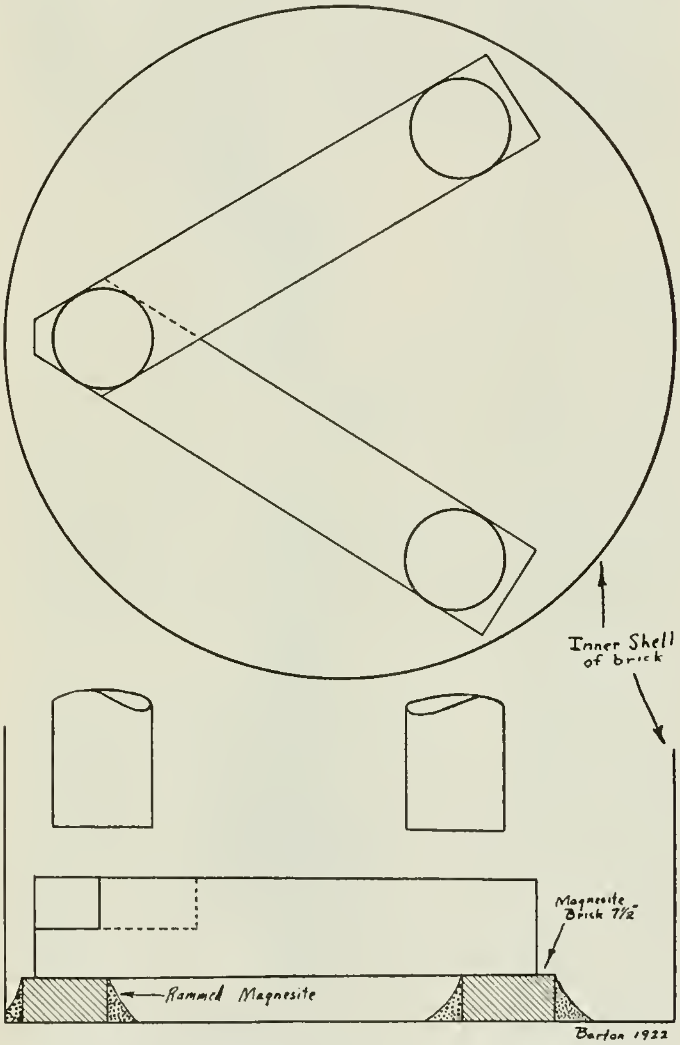


Fig. 4—A more accessible alternative for location of electrodes in furnace bottom. This arrangement shows electrodes well supported.

The best method of taking these tests is by means of a long rod with a flattened, hoe shaped point about two inches in width. This point is pushed into the hearth material at several points, and small samples withdrawn. These samples should show thorough fusion in each case, if not, a section is unburned. During this period it may be necessary to run off load on different electrodes in order to heat one section of the furnace more than another. If trouble is had with fusion in any spot it may be necessary to dust with a small amount of your slag which will melt and run in the crevices thoroughly binding the bottom into one compact body. I have found that a mixture of one part slag to six of magnesite offers a mixture which will give as good results as can be obtained from any set proportion, it always being necessary to change mixtures, depending on the way fusion proceeds. The hearth is gradually built up in this manner until it begins to take a definite shape. It is now good practice to tip the furnace in either direction, in order that the walls may be built up as high as possible. The sections at the jambs can be formed by using the mixture slightly moistened and tapped into shape with rabbles. When the final shape is obtained, as per Fig. 5, the entire hearth should be given a good dusting of slag, and the current held on until this has thoroughly melted, filling any small surface cracks or irregularities. The current is now killed, and the stubs raked from the bottom. The above series of operations should be given plenty of time, and under no conditions should they be forced. The time for a six-ton furnace will average about 24 to 30 hours, and for a three-ton about 20 to 24. A great deal depends upon the experience of the man burning in, as a good operator will conserve every bit of heat and time, resulting in a shorter period of burning.

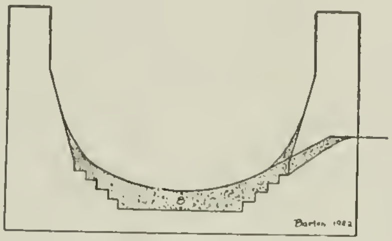


Fig. 5—Final shape of hearth before the dusting of the slag.

The hearth is now in such a condition that a bar thrust against it will ring, as if hit against a concrete wall. If desired a wash heat can now be made to thoroughly set the bottom. I recommend that this heat, if used, be a heat of grey iron made from steel scrap, as this character of a heat will always melt and run clean, and appears to leave the bottom in better condition than any other metal. As soon as this heat is tapped the bottom can be slightly patched if needed, but this is unnecessary if the first burning has been properly done. The walls, above the slag line, can be touched up with a good grade of dolomite, or any of the trade materials such as syndalog, magdalog, etc.

Great care should be taken of the hearth during operations. After each pour some time should be spent in cleaning out small holes in the hearth, and in keeping the slag line clean. Good alloy steels can never be made on a poor hearth, or in a hurry, and it pays to take plenty of time on this subject of repair. Great care should be exercised not to use too much patching material, as it will only come up in the slag on your next heat offering further problems.

The same applies to the nose or tapping spout. It should at all times be kept free of sculls, slag accretions and holes. Magnesite mixed with a small amount of sodium silicate, and well rammed in and dried, offers an excellent material for a good clean spout which will usually last much longer than one built of brick.

Class of Scrap.

In the manufacture of any high grade steel a great deal of the success obtained is due to the character of scrap used. While it is possible, of course, to make good steel from inferior scrap, it follows that every additional operation necessary through this practice greatly increases the conversion cost. Not only that point, but every time you boil the bath, with ore, to either lower the carbon, or to reduce phosphorous, you are placing oxide in direct contact with the metal, offering a splendid chance to have this objectional substance dissolved in the steel, some never to be eliminated. Such scrap as good punchings, ingot or mill butts, heavy plate or structural scrap offers an excellent raw material. Good heavy turnings are also good, if kept clean from oil, dirt, waste, etc. When it is considered that some of this steel in the ingot will cost over a hundred dollars a ton it certainly pays to add a few dollars to the initial scrap charge. Classes of scrap should be segregated mainly on their phosphorous contents, using such metal for each heat as will meet the specification without any unnecessary slagging off.

Raw Materials in General.

Lime should be of good quality, thoroughly burned, and as free of any objectional elements, such as sulphur, etc., as is possible. All car loads should be analyzed completely, and great attention paid to this point. Before using the lime should be crushed to a size of half-inch, or smaller, as time will be here saved when building a slag, which will more than pay for any shorter life of refractories, due to lime dust impinging on the roof or walls and causing a slagging action.

Fluorspar should contain over 85 per cent calcium fluoride, and be as low in silica as is commercially possible. This should also be crushed to about pea size.

Re-carbonizing materials should be low in ash and sulphur. If coal, or other unbaked carbonaceous material is used it should be as low in volatile matter as can be obtained consistent with cost. I have found several materials on the market which are exceptionally good for this purpose. Pitch or retort coke, flake graphite, clean anthracite coal, and similar carbons are all good to use, each filling its purpose well.

Charging Operations.

The charging of the furnace will follow the already common practice of placing the larger pieces on the hearth, and filling the cavities with smaller sized metal. It is often desirable, especially when the bottom is rather low, to charge some of the lime for the first slag onto the hearth before the scrap is charged. It is also often necessary to charge a small amount of coke, when it is desired to melt down under one slag only. Such alloys as nickel and tungsten when charged with the scrap, should be well down towards the bottom so that alloying will gradually proceed as melting progresses.

Plain Carbon Steels—These steels, especially those of from .30 to .55 per cent carbon, find wide use, being used in most forging work, both for light and heavy duty. While it is true that alloy steels are rapidly cutting in on their use there is still a great demand for a high grade metal of this character for such articles as forged gears, cams, crank-shafts, driving rods, axles, etc.

As a good example of this steel we can do no better than to take as an example a specification calling for: Tensile strength, minimum, 100,000 lbs. per sq. in.; El. limit, 65,000 lbs. per sq. in.; Elongation, over 15 per cent.

A steel which will easily meet this is one containing: Carbon, .40/.50 per cent; manganese, .45/.55 per cent. Other analyses standard with a phosphorous and sulphur under .04 per cent.

The furnace is charged with suitable scrap probably analyzing about carbon, .25 per cent; manganese, .50 per cent; silicon, .08 per cent; phosphorous, .04 per cent; and sulphur, .045 per cent, such as is commonly made in the basic open-hearth furnace for rolled work. The current is turned on and the doors closed and sealed. As soon as the electrodes have run down, and are in close proximity to the bottom, the doors are opened, the electrodes raised, one-half of the lime for the first slag thrown into the holes, the holes filled with scrap, and the melting again started. Care should always be taken in this manner to prevent the electrodes digging, and cutting the bottom. The heat will now melt down rather fast. When melting is nearly completed the doors should again be opened, the scrap on the walls shoved in, and the balance of the first slag added. In this instance the first slag will consist of 2 per cent of the charge, lime, and 10 per cent of the lime clear white sand. As soon as all is melted a test of the slag is taken. This should show a dead black, and should be of medium consistency. If too thick it can be slightly thinned with fluorspar—if too thin more lime can be added. When the metal is sufficiently hot the first preliminary test can be taken, poured into a chill, quenched and broken for fracture. This will show very low in carbon and will necessarily be low in manganese and silicon. We will assume this test to be at .08 per cent carbon, with all conditions favorable to slagging off. Shut the current off and hold in this condition for several minutes. If there is a slight boil in evidence a handful of fine ferro-silicon thrown in on the spot will quiet this. As soon as the slag has quieted, the furnace is slighting tipped and the slag drawn off. What will not run free must be raked out with hoe shaped rabbles, well slag covered. When the bath is fairly free a few shovels of fine lime are thrown on its surface, and what slag remains will quickly coagulate and can be removed. A slag of this character made from scrap which is slightly rusty, will remove at least .02 per cent of phosphorous, based upon a volume of 2½ to 3 per cent of the charge.

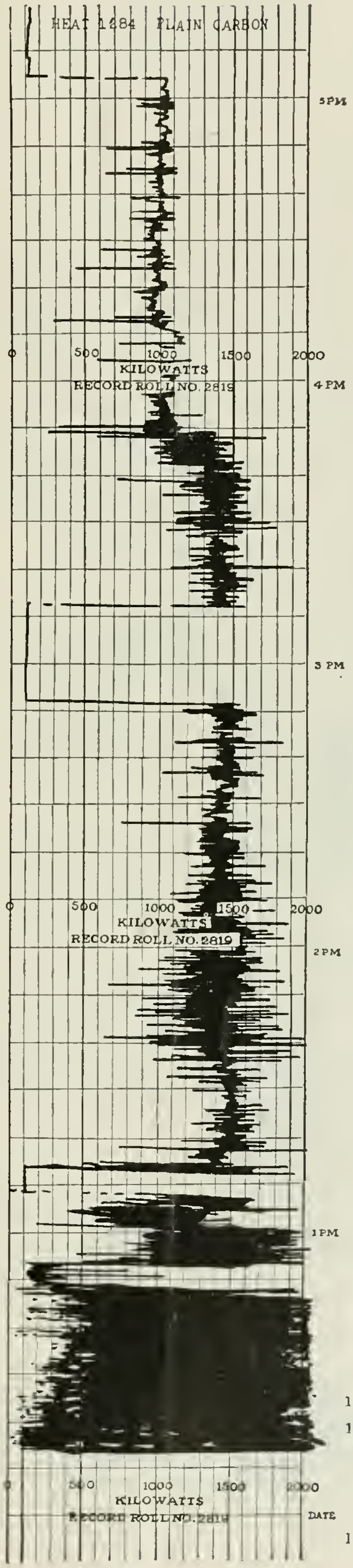
Enough recarbonizer to raise the carbon to .35 per cent, and manganese figured at .30 per cent are now added to the bare metal, and the current turned on. This carbon will usually start a small boil, sometimes rather violent, and often the re-carbonizer must be added in small lots. In about 10 minutes or less the free carbon will all be absorbed, as denoted by the rapid

HEAT LOG OF PLAIN CARBON STEEL

Specifications:		Steel made:	
Carbon	.40/.45	Carbon	.43
Manganese	.45/.50	Manganese	.53
Silicon under	.12	Silicon	.09
Phosphorus and Sulphur, less than	.045	Phos.	.038
		Sulphur	.016

Charge:		Approximate analysis:	
Ingot croppings	8,000 lbs.	Carbon	.25
Boiler plate	6,000 lbs.	Manganese	.50
Heavy turnings	3,000 lbs.	Silicon	.05
		Phos.	.04
Total	17,000 lbs.	Sul.	.04

Material charged as follows: Turnings on the hearth, then the boiler plate, then ingot butts, with about 1,500 lbs. of the latter left to fill up holes as melting proceeds.



5:05—Metal poured.

4:50—Final metal test taken showing excellent conditions. Slag very heavy in carbide.

4:30—Analysis back from chemist at .35 per cent carbon and .40 per cent manganese. .10 per cent manganese added, .05 per cent carbon added directly under the electrodes and rabbled in. Silicon at .10 per cent added. Flame oily with heavy black smoke coming from furnace.

4:15—Slag strongly carbidic. Ferro-silicon figured at .05 per cent added. Doors sealed. Flame brilliant, soot beginning to come out from around the cooling rings.

4:00—Slag test showing light brown, fluidity good, conditions strongly reducing. Metal test taken for chemist.

3:50—Slag well rabbled, given 25 lbs. fluorspar, and another dusting of coke.

3:15—Current again on. Second slag made up containing 300 lbs. lime, 100 lbs. fluorspar, and 50 lbs. ground coke. Added at intervals during the next 20 minutes. Then given a good dusting of ground coke.

2:50—Current off, slag raked from furnace. Three scoops of fine lime added, and balance of slag removed. Metal "dead." Manganese calculated to .25 per cent added together with anthracite coal, figured to .20 per cent available carbon.

2:40—Slag dead black, boil very low. Conditions good.

2:25—Charge all in, 50 lbs. lime and 50 lbs. fluorspar added, bath under a light boil. First preliminary test taken, showing carbon about .10. Slag oxidizing, heavy black, medium fluid.

2:15—Charge nearly melted, 200 lbs. lime and 50 lbs. ore added.

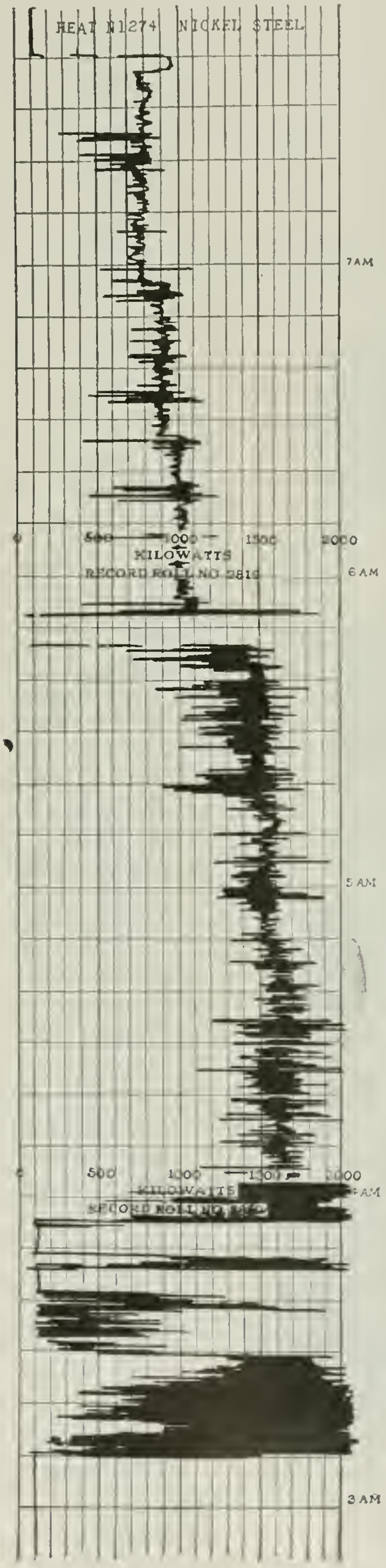
1:10—Holes again filled with balance of scrap on platform.

12:55—Current again on.

12:45—Electrodes down to hearth, current off and 100 lbs. lime added to holes, and the holes filled with scrap.

12:15—Current on.

drop of the flame emitting from the roof ports. One half of the second or finishing slag is now added consisting of 2 per cent of the charge lime; 20 per cent of the lime spar; several scoop shovels of powdered coke; well mixed together. The doors can now be closed, and luted on one side (if in a three-door furnace). In about 10 minutes the balance of this slag can be added, directly under the electrodes, and the slag given a good dusting of powdered coke. During this time the skimming gate has been set and luted, and is now being dried with an oil or gas flame; the ladle is also under the fire.



7:35—Heat poured.

7:25 Final fracture test taken, .15 per cent lump silicon added.

7:00—Chemist reports carbon .30 nickel 3.55, and manganese .52. Furnace sealed and allowed to soak under carbide slag.

6:30—Slag rounding into shape rapidly, conditions excellent. Another dusting of coke, together with 50 lbs. fluorspar added in small portions to different sections of the bath.

6:15—Balance of second slag added and heavily coked. Metal test taken for chemist. Doors sealed.

5:55—Current shut off, and most of the first slag raked off. Ferro-manganese added, and second slag added.

5:00—Metal nearly melted. Slag gradually brought into proper condition during the next 40 minutes, by means of additions of spar and a small amount of sand.

3:10 Current on. From this time until nearly 4 o'clock scrap added together with small additions of lime, to bring total lime up to 2 per cent of the charge.

HEAT LOG PLAIN NICKEL STEEL

Specifications:		Steel made:	
Carbon	.30/ .35	Carbon	.31
Nickel	3.25/3.75	Nickel	3.62
Other elements standard		Silicon	.12
		Phos.	.040
		Sul.	.026

Charge:		Analysis of charge:	
Nickel scrap	11,000 lbs.	Carbon	.30
Ingot butts	4,500	Nickel	2.50
Total	15,500		

Sufficient pig nickel added on hearth to bring charge up to 3.50 per cent nickel, together with 100 lbs. burned lime.

The flame coming from the roof ports will gradually turn from a sharp reddish to a soft luminous one, denoting that reducing conditions are now materializing. The slag can now be examined, both for color, texture and fluidity. This will gradually change from a black or brown, to a lighter brown, through a grey, until the final white carbide slag is obtained. It may be necessary during this period to add either lime or spar to bring this condition about. As soon as the slag powders in the air, and gives off the familiar acetylene odor when quenched, perfect reducing conditions are obtained. The bath is given another good dusting of coke, and another metal test taken. This test goes to the chemist for carbon and manganese, but is also judged at the furnace by fracture. The flame will now gradually die down and either soot or volatilized silicon may be emitted from the furnace. The heat is now under perfect conditions, the sulphur being rapidly eliminated. Ferro-silicon calculated to .05 per cent can now be added to cleanse the steel of any small adhering oxide, and to promote progress of solidity. When the analysis returns the final additions can be made to the furnace, and the final test taken. As soon as all conditions are correct the heat can be poured.

A moist sack is quickly thrust in the nose and the furnace rapidly titled. The sack will hold back the slag for just long enough to allow the metal to rise up over the skim gate, the slag flowing into the ladle on top of the metal. The pouring practice will be handled later.

Chromium Steels—Steels with chromium contents running from .50 per cent up to 2.00 per cent with carbons as specified.

These steels are handled in exactly the same manner as in the proceeding outline for carbon steels, with the addition of chromium added at least 30 minutes before the pour. When the larger additions are made it is good practice to add the ferro-chrome on the sill just inside the door for several minutes before shoving into the bath, as a means of slightly pre-heating. It will also be necessary to slightly change the final carbon additions to compensate for that contained in the ferro-alloy. Chromium is very easily oxidized, and for this reason more care must be taken of the slag than with carbon steels. I advocate adding 10 per cent more chrome than needed to compensate for the slight losses of this metal which will invariably occur, even under the best of conditions.

The Remelting of Chrome Steel Scrap.

In order to conserve this alloy it is manifestly impossible to slag off or your purpose would be completely defeated. The practice must therefore be slightly changed, and this steel will be described as made under the one slag process. The scrap is charged as before, but in addition coke figured to 10 points plus the specification desired is added. If the order called for .50 per cent carbon you would add coke at ,60—if at 1.00 per cent you would add coke at 1.10 per cent. This is to provide the necessary carbon to overcome the rust on the scrap and to cause the heat to melt at a point slightly under your desired figure, calculating to pick up 10 points of carbon during the finishing operation. This figure will naturally change according to the character of the scrap the amount of rust, etc. Rusty scrap will generally lose 20 points on the melt down, while rattled scrap will probably lose less than .05 per cent of carbon. One half the lime is added but no fluorspar or sand, and the heat is melted as under the two slag process.

As soon as completely melted the balance of the slag, mixed with ground coke and fluorspar is added, the bath given a good dusting of ground coke, and the doors tightly sealed. The better seal here obtained, the quicker will reducing conditions ensue. The slag at this period may range from a black to a green grey, depending upon how oxidizing conditions were during the melting. According to the color you will add your ground coke, the darker the color the more you will need. The slag will now seem to hold, but will finally begin to turn lighter in color as reduction proceeds. This period requires expert manipulation in order that the slag may be cleared as quickly as possible without raising the carbon content over that desired. The furnace should be kept closed as much as possible, and soon the change in the flame will show progress. It is possible for a skilled melter to know exactly what is progressing inside his furnace merely by the appearance of this flame, and the sound of his arc. When the slag is in carbide form the final test of metal for the chemist is taken, and final additions are made upon receipt of his report. Within 20 or 30 minutes of the final chrome addition the heat should be poured. The time necessary to hold under the carbide slag before making the final additions will all depend upon the steel desired, the percentage of carbon, etc., but it is well to understand that it is far better to hold too long than to pour too soon.

Nickel Steels Up to Five Per Cent Nickel.

This class of metal can be handled in the same manner as under carbon steels. The nickel can be added with the charge in the form of pig nickel, and the course of the heat pursued. Nickel is extremely hard to lose by oxidation, and requires no special methods of melting. Fractures containing percentages of nickel over 3 per cent show a difference from those of similar carbon steels, and the chemist must be relied upon to a greater degree. Care should be taken with these steels against over heating as this tends to cause over oxidizing. Nickel steel in the wild condition offers one of the most difficult problems the melter has to handle. The best method of coping with such a situation is by constant working of the metal, together with additions of silicon. This is added in lump form, moistened so it will break through the slag into the metal. When the metal shows sound an analysis will have to be made for silicon, and if too high ore will

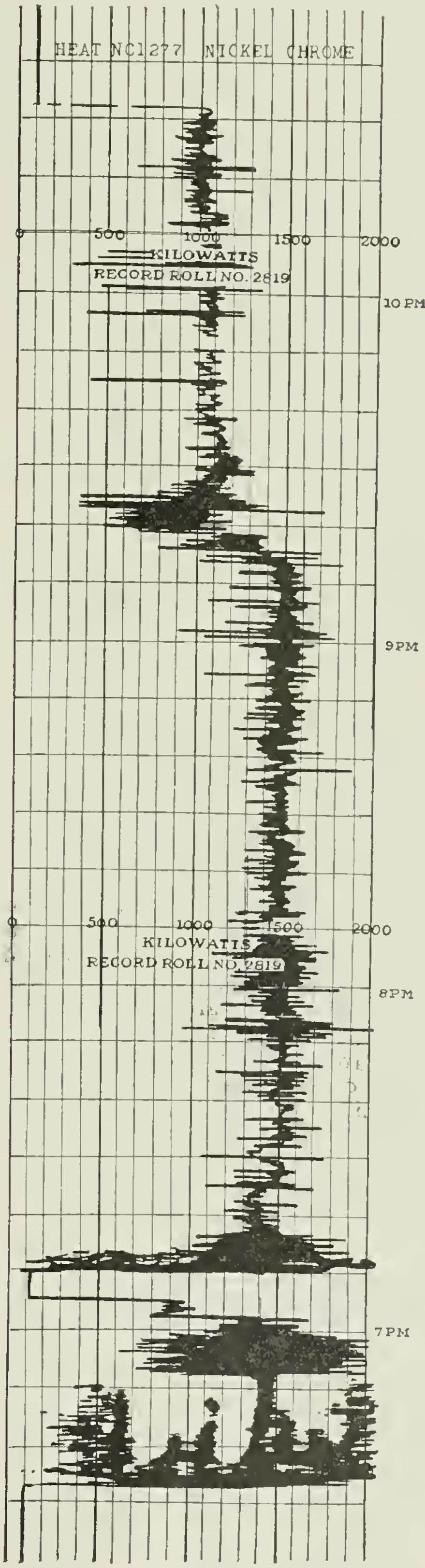
HEAT LOG CHROME NICKEL STEEL

Specifications:
Carbon .25/ .30
Nickel 1.35/1.55
Chrome .50/ .60

Chrome .52
Steel made:
Carbon .30
Nickel 1.51

Charge:
Chrome nickel scrap 14,000 lbs.; analyzing carbon, .24; nickel, 1.50; chromium, .55.

200 lb. lime charged on the hearth, together with ground coke figured at .40 per cent.



10:30—Heat poured.

10:10—Final fracture and slag tests taken.

9.35—Slag in fine condition, showing a faint green tinge on white, but powdering on exposure to the air. Another test taken for analysis. Later came back carbon .27, nickel 1.49, and chrome .33. Sufficient chrome added to bring up to .60, manganese at .10 per cent, nickel at .05 per cent, and given a good dusting of coke.

9:20—Slag in fair condition, but rather thick and gummy. 10 lb. fluorspar added, and thoroughly rabbled in. Bath given a light dusting with ground ferro silicon, and some coke.

6:30—Current on, melted down under similar conditions to a plain carbon heat. As soon as melted a test taken for the chemist, and steps taken to bring the slag to carbide conditions. This heat melted down under a medium brown slag, with conditions more or less neutral. The test came back from the chemist at .24 carbon .37 chrome, and 1.45 nickel.

have to be added, and the heat slagged. Silicon is thus easily reduced, but the steel cannot be classed as real first quality metal. I have found calcium-silicide to be an excellent de-oxidizer under such circumstances as the affinity of calcium for oxygen is so much greater than the nickel that the over oxidized condition is gradually eliminated.

Nickel Chromium Steels.

Handled by a combination of the above methods, depending upon the alloy contents in the raw scrap.

Molybdenum Steels.

This class of alloy steels are best made by the two slag methods of manufacture. After slagging off, and before building the second slag, the alloy can be added in the form of calcium molybdate, the final slag added, and the heat finished under carbide conditions. If ferro-molybdenum is used it should be added to the furnace in a simliar manner to ferro-chrome, after the white slag appears. When handling this metal in combination with such alloys as nickel and chrome they will be added as for their respective classes.

Steels With Vanadium.

The heat is finished and the vanadium added not over 10 or 12 minutes before the pour, giving it just sufficient time to thoroughly diffuse.

Pouring and Ingot Practice.

When using a skim gate on the furnace there is little chance for slag inclusions to appear in the metal. There are, however, always chances for slag to become trapped in the metal stream, small particles of ladle patching, etc., to become contaminated with the steel. As a means of eliminating these troubles I advocate several remedies:

1. Pouring superheated metal and holding in the ladle.
2. Adding a small amount of ground fluorspar to the ladle during the pour.
3. The use of ferro-titanium in the ground form in the ladle.

Superheated metal allows the maximum amount of any foreign inclusion to rise, together with any entrapped gas. Fluorspar will increase the fluidity of any non-metallic particles it encounters, as will the titanium. Titanium also eliminates any nitrogen present by its ability to form the nitride. Aside from the above I do not, under any conditions, believe in any ladle additions whether of coke, manganese or silicon. Aluminum is also eliminated, because in good steel there is no need of this metal, its use giving rise to added inclusions and increasing the shinkage or "pipe." The metal should be of such a temperature that it can stand in the ladle at least 10 or 15 minutes before pouring the first ingot.

All ingots should be cast large end up, and a "hot top" used. This is so common among high grade steel makers that further discussion would be needless. The use of fluted ingots is strongly favored especially in the larger sizes, either in the square or multi-sided shapes. A hollowed base plate gives more satisfaction than a flat one, giving a rounded point to the lower end of the ingot, and aiding in the elimination of base cracks, and cold shuts on the lower surfaces. The interior of the molds should be very well kept, and a wash is favored of either graphite suspended in water and applied to the hot mold, or of lampblack in linseed oil. A slightly higher cost of mold upkeep will always pay for itself in better ingots, with less scrap. The life of ingot molds can be prolonged by giving them a thorough anneal before the primary heat. Any small scabs can often be welded and ground, often resulting in many heats from a mold which normally was due for the scrap heat.

Top pouring of ingot molds is favored over the method of plate pouring for the reason that invariably runner brick will cut and peel, the silica inclusions remaining in the ingot. Molds should be "cold poured" the nozzle opened just far enough for the steel to rise with a "creamy top." Under no conditions should a stop occur during the pouring of an ingot, for a seam is bound to result, and while it may only be on the surface it often crops up in the finished forging after much expense has been spent on its fabrication. There are certain cases, as in a large ingot, where bottom pouring must be resorted to. For such class of work it is desirable to fill the mold about one-third to one-half full, and then finish by top pouring. The hot top is then set and the ingot filled. The best hot tops are those made from well burned bricks of good material, sand molded ones offering a chance for inclusions to creep into the metal.

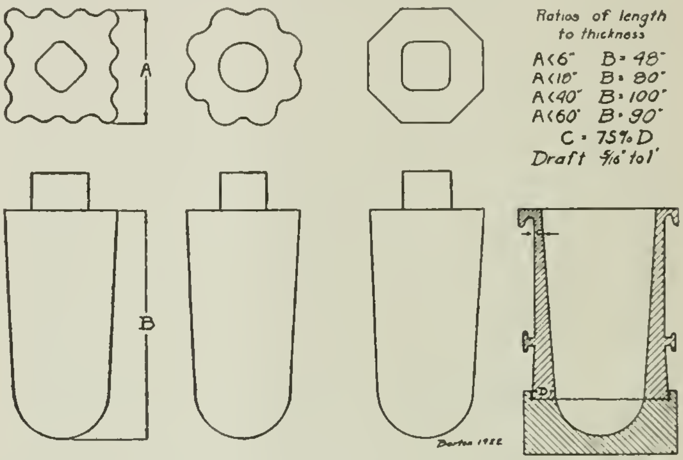


Fig. 6—Sketches of approved ingot and mold design used in top pouring, with hot tops.

Ingots should be stripped as soon as possible and allowed to stand end up until perfectly solid, when they may be placed in the soaking pits. This condition is obtained when the corners begin to show slightly black. Fig. 6 shows some sketches of ingot and mold design which have proven acceptable for the above described work.

RAILWAY DEPARTMENT EMPLOYEE TRANSFERRED

E. D. Lynch, Railway Department, Westinghouse Electric & Manufacturing Company has recently been transferred to the New Haven office of that company. Mr. Lynch has been engaged in railway activities since graduating from the Baltimore Polytechnic Institute. He was engaged in assisting in the negotiation work of the Railway Department, but at a reorganization of the Railway Department, he was appointed Office Manager of the department. At New Haven Mr. Lynch will fill the vacancy made by Mr J. P. Alexander's removal to the Boston office of the Westinghouse company.

By-Product Coke Oven Operation "10" Pushing Series

Uniformity of Products Depends upon Correct Series—Close Approach to Theoretical Correctness—Other Important Factors —Diagrammatical Demonstration.

By A. COE

PROBABLY no one operating feature of a by-product coke plant has been more thought of, discussed and theorized upon than the pushing series. It receives consideration as the time approaches for starting up the new plant and in existing plants, as its importance is recognized and every effort is made to get the best possible results. It is now generally conceded that "uniformity" of operation of a coke plant, particularly the batteries, gives best results as to the life of the apparatus and as to quality and yield of coke; raw, surplus and fuel gas; tar and other by-products. "Uniformity" of operation should be uniformily good operation. However, some plants are not capable of uniform operation, not necessarily because of faulty design or construction, but from such factors as non-uniform coal supply, etc. It is because of this desire for uniformity that the pushing series has been given so much consideration. Without doubt the best "10" pushing series has been in use for many years (we discuss the "G" series later); it is generally conceded that the only practicable pushing series is a "10" series; as is evidenced by the fact that probably without exception, every by-product coke plant uses a "10" pushing series.

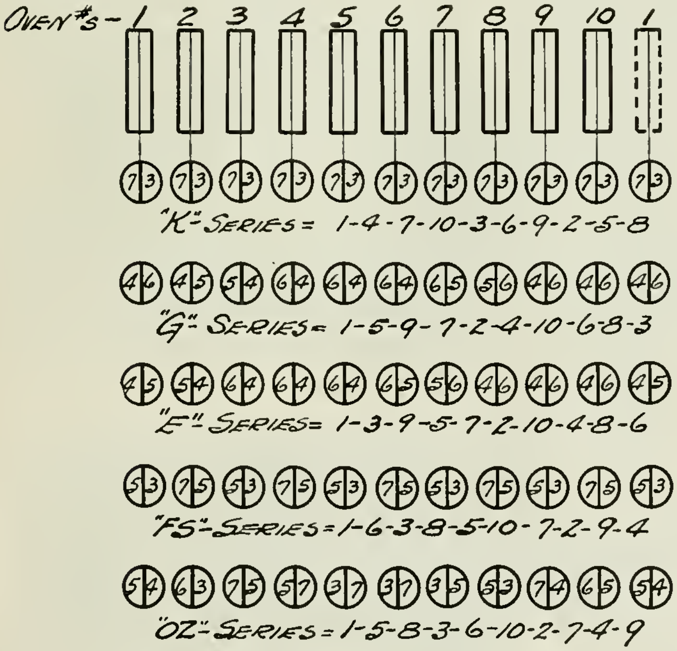


FIG. 1—PUSHING SERIES—The above diagram shows, for various pushing series, the age, in series, of the first oven to the right and the first oven to the left when any oven is pushed. For instance when oven No. 7 of the "G" series is pushed the first oven to the right (No. 8) is 5 series old and the first oven to the left (No. 6) is 6 series old. Series difference is the hours difference when the gross coking time is 10 hours, or in direct ratio for any other coking time—for instance, "G" series, if the coking time is 20 hours: **When oven No. 7 is pushed, oven No. 8 is 20 x 5/10 = 10 hours old and oven No. 6 is 20 x 6/10 = 12 hours old.**

Some have thought that the importance of the pushing series warranted using some other than the "10" series and have proposed an "11" or other series, upon the assumption that the ideal pushing series would be one in which the age of the first oven on each side of the one pushed would be exactly one-half the gross coking time. It would seem that this assumption can be proper only if exactly one-half the Btu. are required and have been absorbed by the coal charge when one-half the coking time has elapsed, which seems unlikely; or if there is an exact heat balance as between each exactly one-half the gross coking time. It seems logical that either more or less than one-half of the Btu have been absorbed by the charge when one-half the coking time has elapsed, rather than exactly one-half have been used, particularly when allowance is made for the actual (net) coking time being less than the gross coking time due to time between

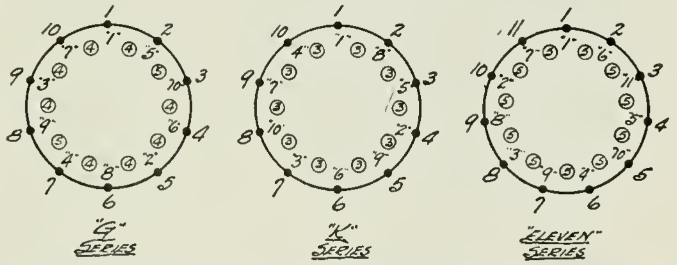


FIG. 2—PUSHING SERIES—Oven numbers outside of circle. Sequence numbers inside of circle, in quotation marks. Minimum difference in series in rings, inside of circle. To obtain the "pushing series," after having established the order of the "sequence numbers" by means of the "minimum difference in series": First, write the "sequence numbers," in numerical order: Sequence numbers = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10: "G" Pushing Series = 1, 5, 9, 7, 2, etc. Second, write under the sequence numbers the oven numbers opposite them (on outside of circle). To obtain the number of "series" differenct between any two ovens, proceed as follows: "G" pushing series = 0, 1, 2, 3, 4 (5 forward / 1, 5, 9, 7, 2, 4, 10, 6, 8, series between oven No. 1 and No. 2) / 3, 1. 0, 1, 2, 3, 4, 5, 6 (6 reverse series between Ovens No. 2 and No. 1). New series may be obtained from any series by revolving the (oven) numbers outside of circle around the numbers inside of circle: Revolving "G" Series one number counterclockwise we obtain: 1, 7, 9, 4, 2, 6, 10, 8, 3, 5. (See also "8" of the text.)

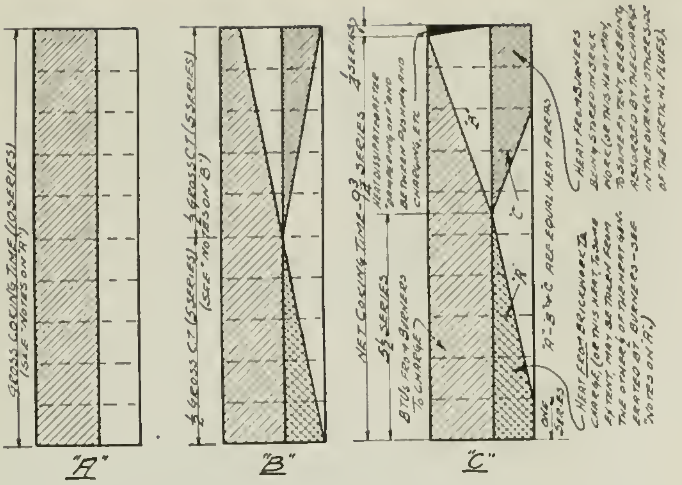
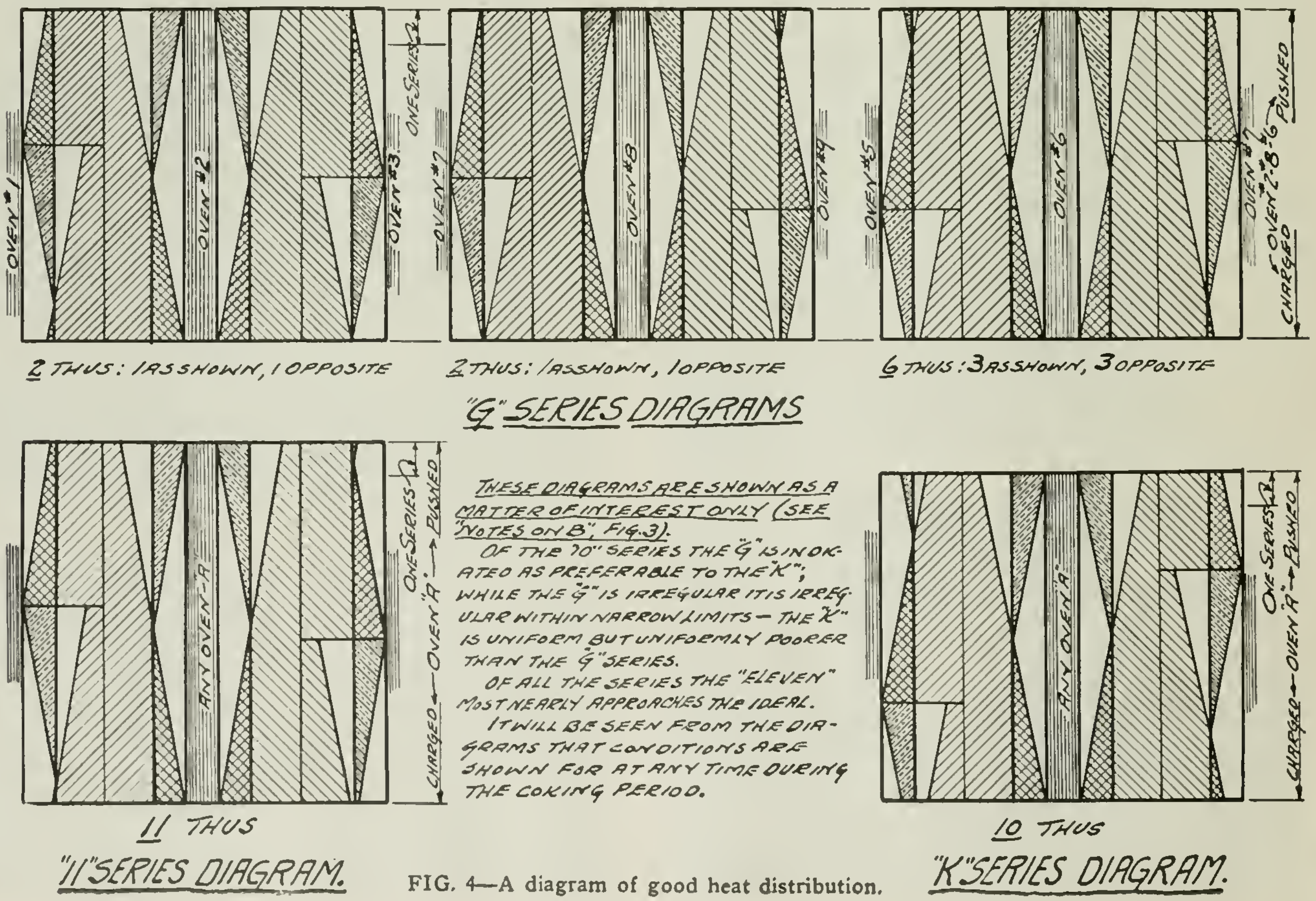

GROSS COKING TIME (10 SERIES) (SEE "NOTES ON 'A'")
½ GROSS C.T. (5 SERIES)
½ GROSS C.T. (5 SERIES) (SEE "NOTES ON 'B'")
NET COKING TIME - 9¾ SERIES
¼ SERIES
HEAT DISSIPATED AFTER "DAMPERING OFF" AND BETWEEN PUSHING AND CHARGING, ETC.
5¼ SERIES
BTUs FROM BURNERS TO CHARGE
"A" - "B" & "C" ARE EQUAL HEAT AREAS
HEAT FROM BURNERS BEING STORED IN BRICKWORK (OR THIS HEAT MAY, TO SOME EXTENT, BE BEING ABSORBED BY THE CHARGE IN THE OVEN ON OTHER SIDE OF THE VERTICAL FLUES)
HEAT FROM BRICKWORK TO CHARGE (OR THIS HEAT, TO SOME EXTENT, MAY BE TAKEN FROM THE OTHER ½ OF THE HEAT GENERATED BY BURNERS - SEE "NOTES ON 'A'")
ONE SERIES
"A"
"B"
"C"

Fig. 3—In the following only the heat absorbed by the charge is considered. The heat in the stack gases and radiated to the atmosphere by the battery as a whole are not included—the heat to the stack gases and atmosphere are practically uniform, except for atmospheric changes and conditions. Notes on "A"—This diagrams the heat uniformly generated, in other words the heat (Btu.) uniformly supplied, throughout the coking period, for the oven on one side of the vertical flues. It shows only one-half the heat generated or Btu. supplied, the other one-half going to the oven on the opposite side of vertical flues. Notes on "B"—This diagrams the distribution of the heat supplied and shown by "A," as it is commonly considered to be distributed, that is an exact heat balance as between each exactly one-half the gross coking time together with no allowance being made for conditions between "dampering-off" and pushing and between pushing and charging (the notations to "C" apply descriptively to "B"). Notes on "C"—This diagram is submitted as showing more nearly actual conditions—see Notes in "B." It is fully explained by notations at the diagram.

"dampering off" and pushing, and between pushing and charging, etc. It is a reasonable assumption that more than one-half the Btu. are required for the first one-half of the coking period considering that the charge has to be heated from atmospheric temperature, water content heated to about 212 deg. F. and converted into vapor; this vapor raised to a higher temperature and probably the greater percentage of the tar distilled off in the early part of the coking period.

An attempt has been made in the following discussion and by means of the diagrams to show that with only our present knowledge of heat distribution and the coking operation a change from a "10" to an "11" or other series, is not warranted and that the "G," a "10" series, is better than other "10" series and the best obtainable. To do this, it has been necessary to make what are considered reasonable assumptions as to heat distribution, but without any actual data, as shown by Fig. 3 C and by Fig. 5 curves might have been plotted instead of straight lines, which would perhaps make a better appearance. Straight lines were used to make the work easier. Granting that the assumptions made are reasonable, it will be seen that there would be very little practical difference in operating results for example, as between the "G," a "10" series, and the "11" series.

In practice, with the best "10" pushing series obtainable (the "G" series), probably one oven is wholly or partially very slightly more coked and another very slightly less coked, or a charge may be slightly more coked from one side than the other but in this case their variations would be small. In the case of other than the best and depending upon the particular pushing series it would seem as though there must be over-



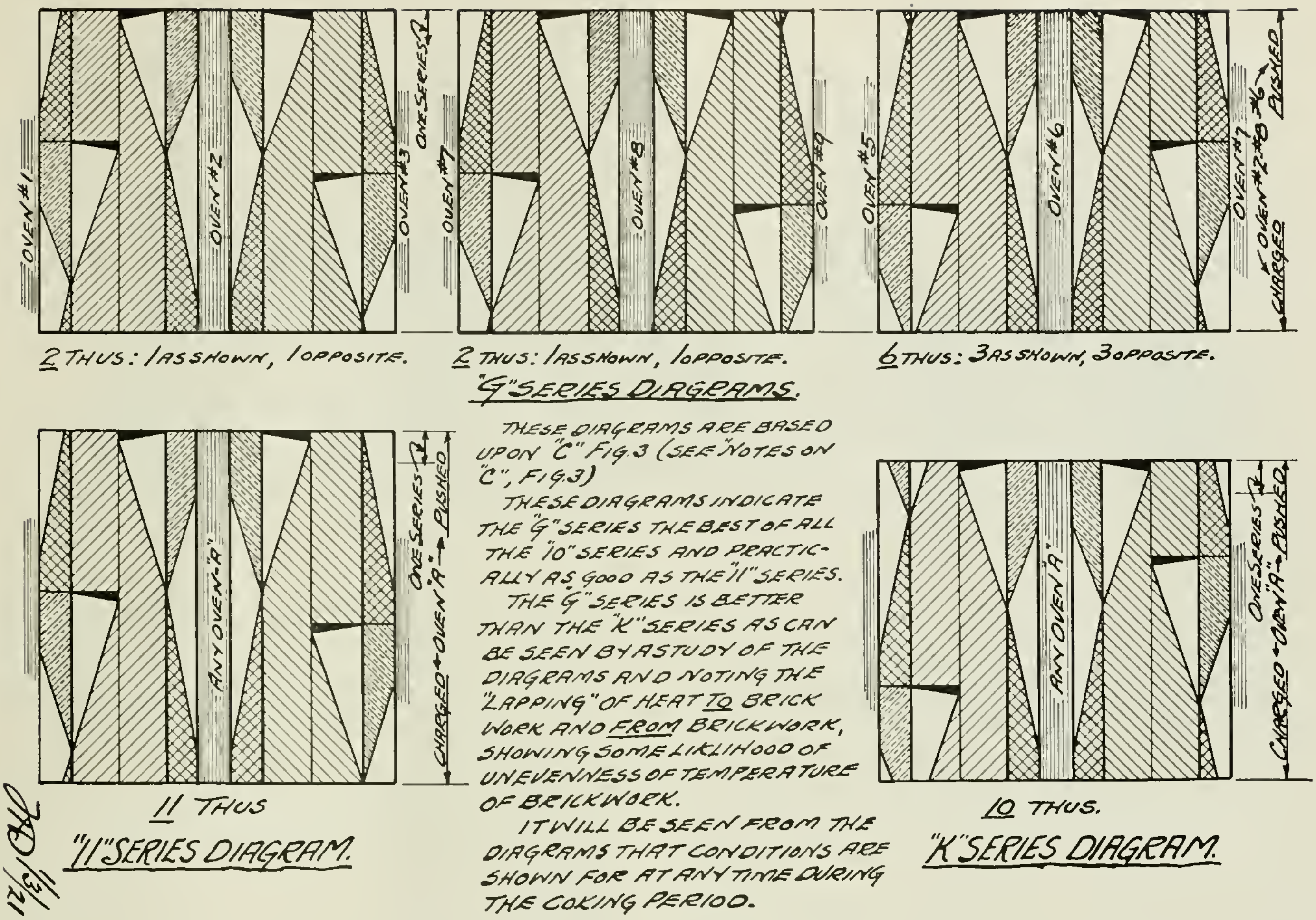
THESE DIAGRAMS ARE SHOWN AS A MATTER OF INTEREST ONLY (SEE "NOTES ON B", FIG. 3).

OF THE "10" SERIES THE "G" IS INDICATED AS PREFERABLE TO THE "K"; WHILE THE "G" IS IRREGULAR IT IS IRREGULAR WITHIN NARROW LIMITS — THE "K" IS UNIFORM BUT UNIFORMLY POORER THAN THE "G" SERIES.

OF ALL THE SERIES THE "ELEVEN" MOST NEARLY APPROACHES THE IDEAL.

IT WILL BE SEEN FROM THE DIAGRAMS THAT CONDITIONS ARE SHOWN FOR AT ANY TIME DURING THE COKING PERIOD.

FIG. 4—A diagram of good heat distribution.



THESE DIAGRAMS ARE BASED UPON "C" FIG. 3 (SEE "NOTES ON "C", FIG. 3)

THESE DIAGRAMS INDICATE THE "G" SERIES THE BEST OF ALL THE "10" SERIES AND PRACTICALLY AS GOOD AS THE "11" SERIES.

THE "G" SERIES IS BETTER THAN THE "K" SERIES AS CAN BE SEEN BY A STUDY OF THE DIAGRAMS AND NOTING THE "LAPPING" OF HEAT TO BRICK WORK AND FROM BRICKWORK, SHOWING SOME LIKLIHOOD OF UNEVENNESS OF TEMPERATURE OF BRICKWORK.

IT WILL BE SEEN FROM THE DIAGRAMS THAT CONDITIONS ARE SHOWN FOR AT ANY TIME DURING THE COKING PERIOD.

FIG. 5—Another example of good heat distribution.

coking and under-coking of the charge and uneveness of temperature of the oven brick-work.

With the best "10" pushing series obtainable (or even with the so-called "ideal" pushing series, granting such a possibility) together with a knowledge of theoretically correct heat distribution it would probably be impossible to obtain an absolutely uniform supply of Btu. to the individual vertical flues of any oven or to the individual oven of any battery and so forth. If anything like proper heat regulation exists, as to the individual flues or ovens, the difference between the results obtained and absolute perfection are very small indeed.

There are many other factors of more or less importance entering into the uniform heating of the oven charges as a whole, other than the pushing series and the heat "regulation." Of these many factors may be mentioned the "radiation" from the battery as a whole, the total Btu. required for coking the charge depending, to some extent upon atmospheric temperature with or without rain, snow, wind, sunshine, etc. Again the Btu. required to be supplied to successive charges for any particular oven depend somewhat upon the temperature of the charge, its moisture content and the "weight" of the charge (assuming constant volume). The total weight charged per oven varying with the moisture content, percentage of fines to coarse in coal only crushed, etc.

Referring to Fig. 1 the "K" series may be described as "uniform"; the "G" and "E" series as somewhat irregular, but giving identically the same operating results. The "FS" series as a combination uniform—irregular; and the "OZ" series as entirely irregular. We should say that the "FS" and "OZ2" series would give very uneven temperature of oven brickwork and ununiform coking of the charge throughout the coking period with its consequent ill effects on coke, by-products, etc., and oven brick-work.

The series most used are the "G" series, or those that may be derived from it, and the "K" series. Other "10" series commonly used are not to be compared to the "G" and "K" series. The "E" series may be obtained from the "G" series (see Fig. 2) by revolving the "minimum difference in series" one space counter-clock-wise and thus obtain the new arrangement of "sequence numbers" 1, 6, 2, 8, 4, 10, 5, 9, 3, 7. The "E" series is obtained as previously explained from the "G" series Fig. 2. An "11" series derived as explained in Fig. 2 is, 10, 8, 6, 4, 2, 11, 9, 7, 5, 3, 1.

Figs. 1 and 2 indicate briefly the method of deriving and portraying a pushing series without the aid of mathematics. They were evolved by the writer in 1915 to indicate which of several "10" pushing series is the best. The writer demonstrated at that time that the "G" series was preferable as shown by Fig. 1. Fig. 2 only briefly describes the method of deriving a pushing series, since it is thought that the reader knowing that the best "10" series already exists (the "G" series), and will not care to derive other series. If he should, it is considered that enough explanation is given to serve the purpose. Figs. 3, 4 and 5 elaborate upon Figs. 1 and 2 and further demonstrate the "G" the best of the

"10" series and as good as can be obtained, being in the writer's opinion, practically as good as the "11" series

The problem of choosing a pushing series is not to obtain the same heat treatment for all ovens (as is given by the "K" and "11" series) unless this is obtained together with other advantages. Nor is it a problem of the best "average" heating of all the ovens, because in this case some ovens might be very good and some very bad and still have the best average. The problem is to choose a compromise as between uniformity and irregularity, such as is given by the "G" series as shown by Figs. 1 to 5, inclusive. Consideration should be given to "evenness" of temperature of the oven brick-work throughout the coking period. The temperature should not be higher at one time of the period and lower at another, as this condition, at least if excessive, shortens the life of the oven brick-work. However, uneveness of temperature probably cannot be entirely eliminated with any series. From the diagrams of Figs. 3, 4 and 5, we conclude that the "G" series and the "11" series would give a more nearly uniform temperature of the oven brick-work and more uniform coking of the charge throughout the period than the "K" series.

By means of diagrams Figs. 3, 4 and 5 the writer believes he has made a consideration of the pushing series much easier. These diagrams were decided upon only after the consideration of many others.

This discussion of the pushing series has been made as brief as possible, since the proposition involves the whole theory of oven-heating and the distillation process and unless considered in the simplest way possible, might result in one becoming involved in a maze of theoretical and practical considerations. For instance, it is conceivable that the charging of any particular oven may, even if only for a short period of time, decrease the flow of heat slightly to the contents of the chamber two ovens away, depending upon the pushing series used. Or there might be a slight flow of heat from the contents of the next oven to the oven just charged depending upon its age, etc. Increase in temperature of waste gas from one oven would affect all ovens, however slightly any leakage through the oven walls either way would affect that oven and all ovens. Such conditions may be neglected in considering the pushing series.

To obtain advantages over the "10" series would require a quite large series. Such a series would make it necessary to have all the ovens in several batteries in one row worked as one battery and would be impracticable for many reasons such as confusing results from the pushing series itself, great movement of oven machinery, involving much loss of time, etc.

Mention should be made of a very fine mathematical treatment of the pushing series with particular stress upon the advantages claimed for the "11" series by Mr. William B. Marquard, U. S. Patent Number 1,323,711. This paper treats very exhaustively of the pushing series and draws comparisons between the "10" and "11" and other series.

NEW YORK MEETING OF A. S. M. E.

More than 2,000 engineers representing practically the entire range of American industry will attend the annual meeting of the American Society of Mechanical Engineers, to be held in the Engineering Societies Building, New York City, December 4 to 7. This meeting, planned as the biggest in the society's history, will attract leaders in engineering, education, economics and numerous fields of technology from every section of the country. Fully 10 per cent of the society's membership, now approaching 20,000, is expected to participate in the proceedings, the complete program for which has just been announced.

A central feature of national interest will be the joint session Wednesday evening, December 6, with the American Economic Association. E. M. Herr, president of the Westinghouse Electric & Manufacturing Company, will speak on "The Human Problem in Industry." Dr. Wesley C. Mitchell of Columbia University will deliver an address on "Making Money and Making Goods." Prof. H. R. Seager of Columbia, president of the American Economic Association, will lead the discussion, in which President David Friday of the Michigan Agricultural College, Dean Dexter S. Kimball of Cornell, president of the American Society of Mechanical Engineers, and other well known economists and engineers will share. This meeting will mark the growing union of effort between the economist and the engineer.

The ordnance division, of which army officers are among the leaders, has arranged for the following speakers: Major J. B. Rose, U. S. A., Fort Leavenworth, Kan., "Machining and Lapping Very Deep Holes"; R. A. Vail, Detroit, "Manufacture of Gun Recoil Mechanism." Recent ordnance developments will be illustrated by motion pictures.

At the management session, ten years of progress in management will be outlined by L. P. Alford of New York. Wallace Clark of New York will deal with "The Installation of Management Methods," and W. L. Wotherspoon of New York will discuss "Refining and Rolling Mill for Monel Metal." Chester B. Lord of Richmond, Ind., will deal with "A Visual Method of Control." Committees on Measurement of Managerial Ability, Standardization of Terminology and Standardization of Graphics will present reports to their chairmen, A. L. De Leeuw of New York, F. E. Town of New York and John J. Swan of New York.

On the opening day of the meeting there will be a session on "Training for the Industries," at which these reports will be submitted: Extension and Correspondence Schools, by James A. Moyer, Boston; Schools for Apprentices and Shop Training, by R. L. Sackett, dean of engineering in Pennsylvania State College; Industrial Education as Represented in Schools, C. R. Richards of Cooper Union.

At the safety engineering session on December 7, M. G. Lloyd, chief of the Safety Section of the United States Bureau of Standards, will speak on "Safety Codes," M. C. Goodspeed of Erie, Pa., leading the discussion. Other speakers at this session will include A. D. Risteen of Hartford, Conn., and G. E. Sanford of Detroit.

Speakers at the power session will include G. A. Crook and W. S. Morrison of New York, Linn Helander of East Pittsburgh, Pa.; Paul W. Thompson, S. S. Sanford and Sabin Crocker of Detroit, and B. N. Broido of New York.

Addresses at the fuels session will be made by Thomas A. Marsh of Chicago, G. I. Bouton of Detroit, H. F. Lawrence of Philadelphia and A. H. Blackburn of Worcester, Mass. Alfred Cotton and John Hunter of St. Louis will speak on "Ash Handling" at the Materials Handling session.

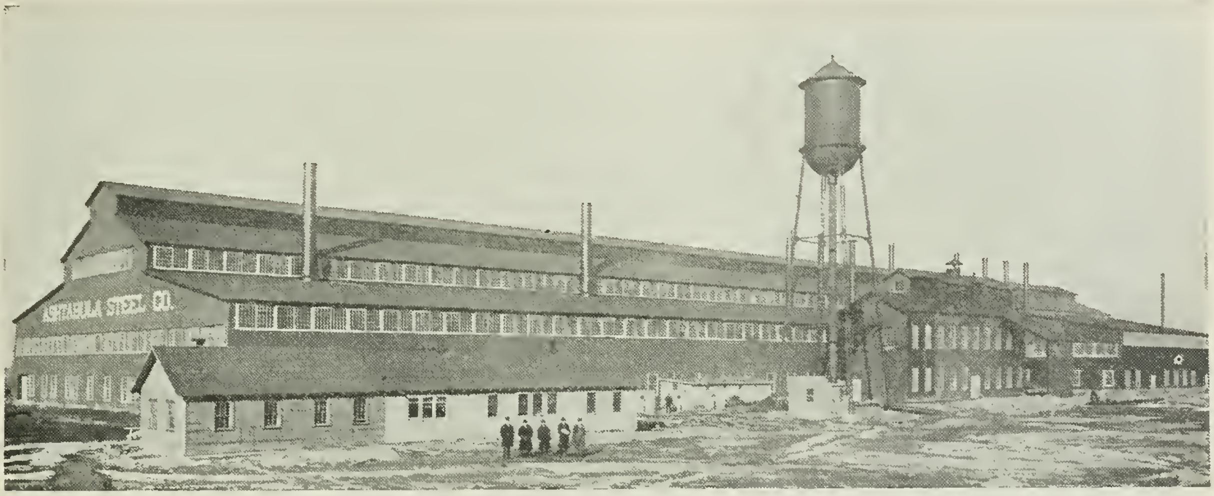


Fig. 1—View of the recently completed sheet steel plant of the Ashtabula Steel Company.

Sheet Steel Plant in Ashtabula Completed

Ideal Location Makes for Favorable Buying and Selling—Pulverized Coal Firing Used Throughout—Rolling, Annealing and Galvanizing Discussed.

By FRED J. CROLIUS

THE same public spirit which manifested itself in the beautiful Ashtabula Hotel — a community sense of unselfish co-operation, a compounding of individual effort through a Chamber of Commerce which actually functions, not annually but hourly—this same combination of constructive forces built the Ashtabula Steel Company, and these same forces will expand it to its logical boundries, and will surround it with the creature comforts of a progressive city. Almost the entire financing aggregating nearly $1,500,000 was done locally by the citizens of Ashtabula city and county.

A better site for this particular character of development would be difficult to select. Situated about two miles east of Ashtabula, almost within sight and sound of the mammouth ore and coal transfer docks of Ashtabula Harbor, long famous as one of the very fine Lake Ports, where more ore was handled in 1920 than in any other port in the world, its transportation facilities are unrivaled. The New York Central R. R. adjoins the plant property with a track frontage of 3,500 feet. The property comprises some 48 acres of level ground. Close transfer to the Pennsylvania R. R. and the Nickel Plate furnishes railroad competition from the best raw material supply points and ready shipment facilities to the cream of sheet steel markets. These three roads offer direct routings and rapid deliveries to the Cleveland, Pittsburgh, Detroit and Chicago districts.

Principle raw material supplies—necessary in the operation of this type of mill—coal, sheet bars, spelter, are immediately available under competitive conditions, and in emergencies can be secured over night. Labor, both skilled and unskilled, can be found here if anywhere, as living conditions, nearness to farms and lake operations are unusually favorable.

General Plant Layout.

The plant itself leaves little to be desired—it is the very last word in design and construction for a milling operation.

The aim was to roll and finish sheets—plain, black galvanized, annealed, corrugated. There was no other confusing alternative.

The entire design of the plant and structure was subordinated to that one aim; the result is "a sheet mill second to none."

The general character of the plant scheme may be said to revolve about the fuel development. Pulverized coal was the fuel selected, and the engineering advantages inherent in this flexible form of heat units have shown a strong influence on all subsequent operations. Where hand firing or stokers require the transport and storage of coal scattered promiscuously about a mill, where producers carry with their operation a certain amount of dampness, ashes and clinkers—this plant has none. It is as clean and dry as a natural gas fired plant; even the boiler house, which instead of being an undesirable eyesore, is actually a spot of interest, a desirable part of the plant power-house.

A description of the plant layout and mill may well start with a discussion of the power-house and fuel minimum of labor and superintendence.

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*Engineering Editor.

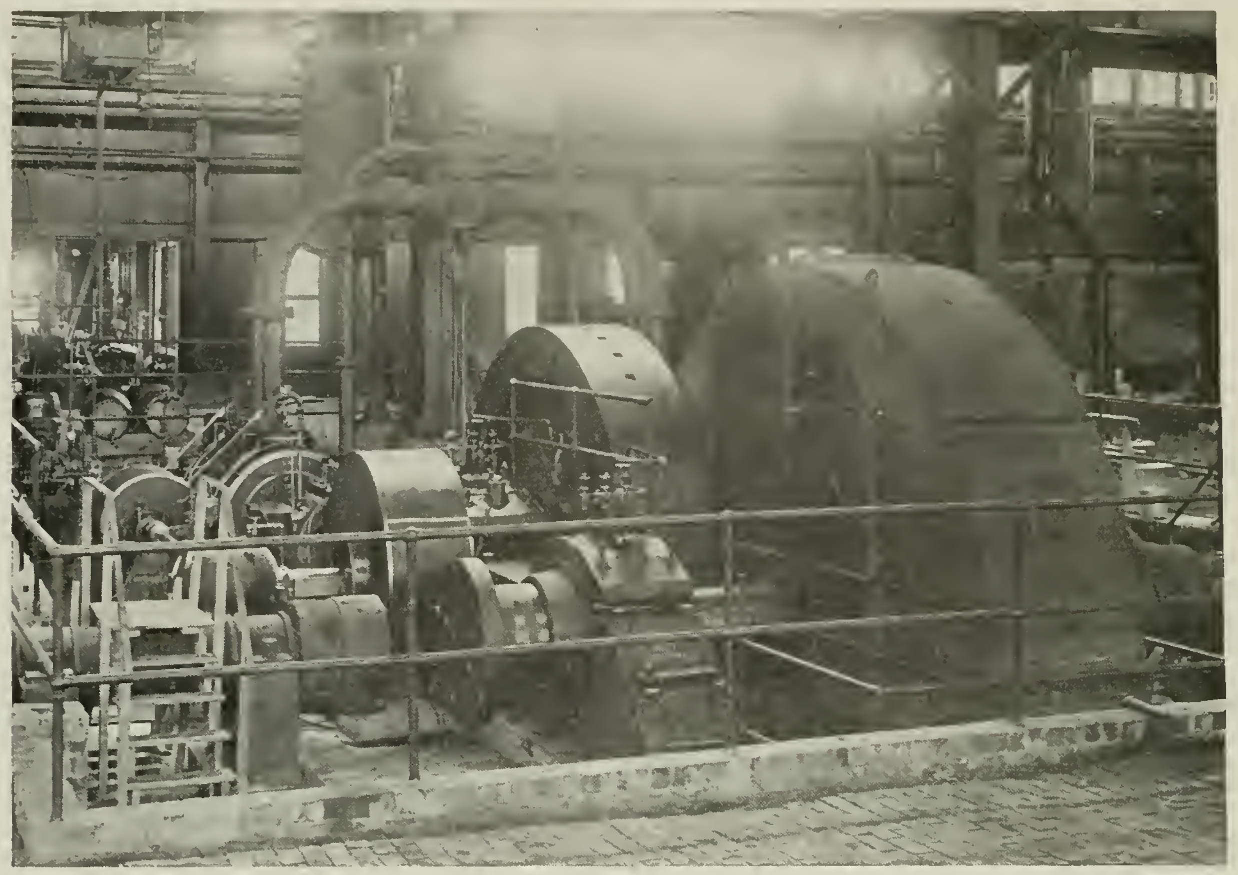


Fig. 2—1600-hp. Nordberg Uniflow engine which drives the rolls. This engine revolves at a speed of 150 rpm. and is geared through Falk gears to 30 rpm., the normal roll speed.

Power House.

Reference to the general plan, Fig. 3, will show these departments separately housed in adequate buildings, contiguously located at most advantageous points for shortest steam lines and powdered coal distributing lines. Every feature that contributes to safety has been complied with.

Two 450 hp. Union Iron Works horizontal water tube boilers, with Foster superheaters, operating at various over-ratings, generate steam at 180 lbs. pressure and 100 deg. F. superheat. Adequate combustion chambers allow a continuous operation, non-clogging, even on the poorest grades of coal over monthly periods. Excellent cleaning facilities have been provided so that a minimum of labor maintains uniform results.

A single fan-tail burner, horizontally placed in the front wall of the extension furnace of each boiler insures excellent combustion of the finely powdered coal.

The power plant engine is a 750-hp Nordberg Uniflow with 22 in. by 32 in. cylinder operating at 150 rpm. direct connected to a 350-kw a.c. General Electric generator and a 175-kw. Crocker Wheeler d.c. generator mounted on the same shaft. Off the same shaft, belt driven at 750 rpm. is operated one 450-kva., d.c. General Electric generator; 3 phase, 60 cycle, 240 v. is used in alternating current generation, while 250 volts are used in d.c. generation. Also one 60-kw. Crocker Wheeler-Buffalo engine direct connected unit is used when starting.

Steam driven auxiliaries consist of; two 10 in. by 6 in. by 10 in. Worthington duplex boiler feeder governed by "S-C" pump governors; (S. C. feed water regulators control and boiler feed regulation).

One 40 hp., 1150 rpm. DeLaval turbine is used to drive direct on the same shaft; a 1600-gal. centrifugal pump to the Ingersoll-Rand condenser and a 2000 gal. centrifugal pump to the cooling pond; both operating against a 35 ft. head. The cooling pond is equipped with 4 stands of 30 spray nozzles each. Approximately 40,000 lbs. of water per hour are evaporated, condensed, cooled and re-used. An 8 in. by 8 in., 22 in. by 8 in. Ingersoll-Rand Vacuum engine functions with the condenser.

Circulating and conveying air for coal to the boilers is furnished by one 40 hp. DeLaval Turbine direct connected to a fan unit operating at 3400 rpm.

Motor driven auxiliaries consist of—two 75 hp. motors driving the two Fuller-Lehigh pumps; two 25 hp. motors driving the two Fuller Kimyon pumps; two 25 hp. motors driving the screws from boiler fuel storage bins; one 20 hp. Allis-Chalmers emergency air circulating pump; one 15 hp. on Nat. Brake & Elec. Company air compressor, delivering at 1155 rpm, 90 lbs. air for Fuller Kimyon distributing system.

Pulverizing Equipment.

Two Standard 42-in. Fuller-Lehigh coal pulverizers of the fan discharge type, combined capacity 10 tons per hour discharging directly through individual 6-in. Fuller Kimyon pumps into the 5-ton tanks or weigh

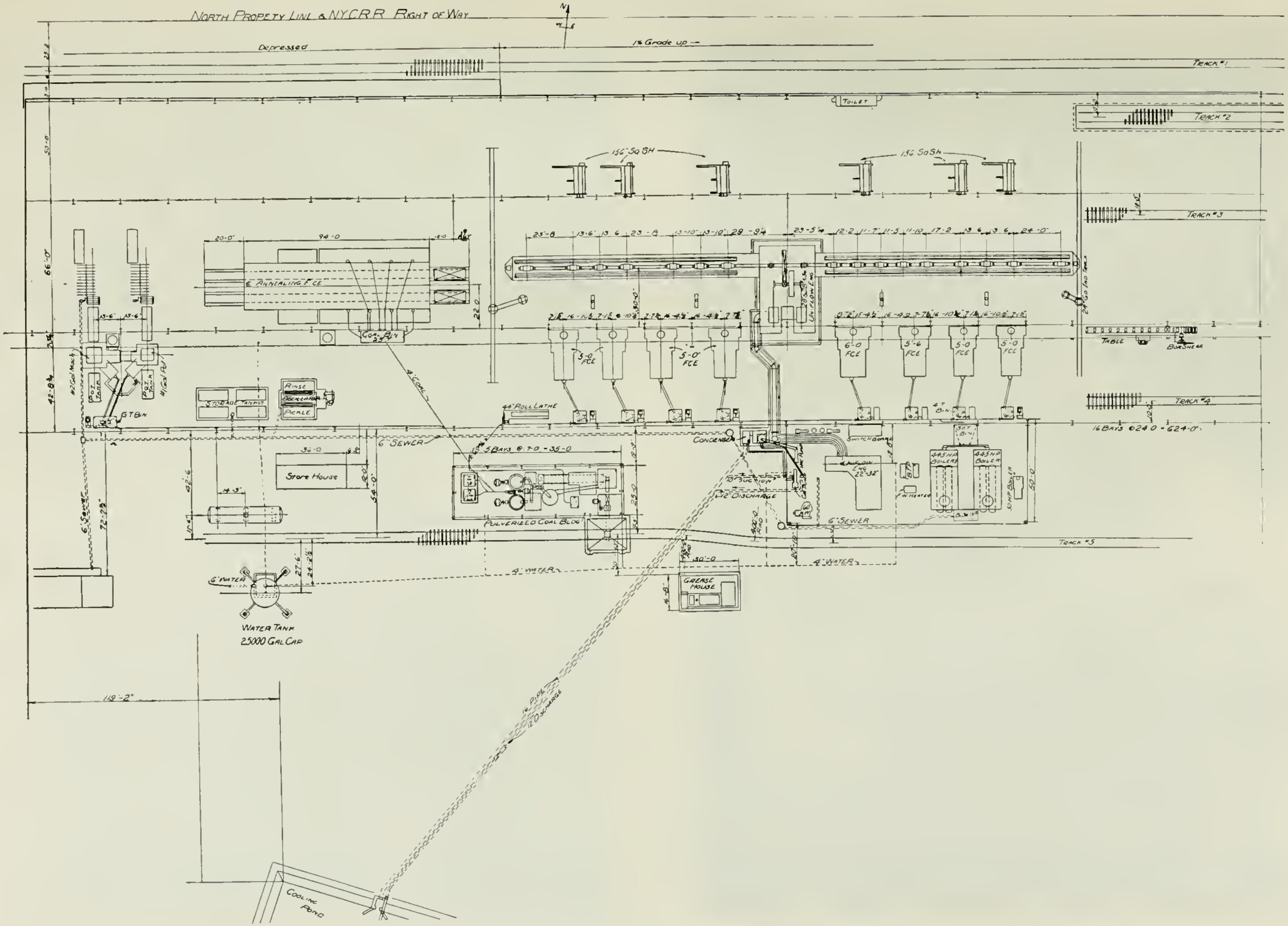


Fig. 3—Plan view of the new sheet steel plant at Ashtabula

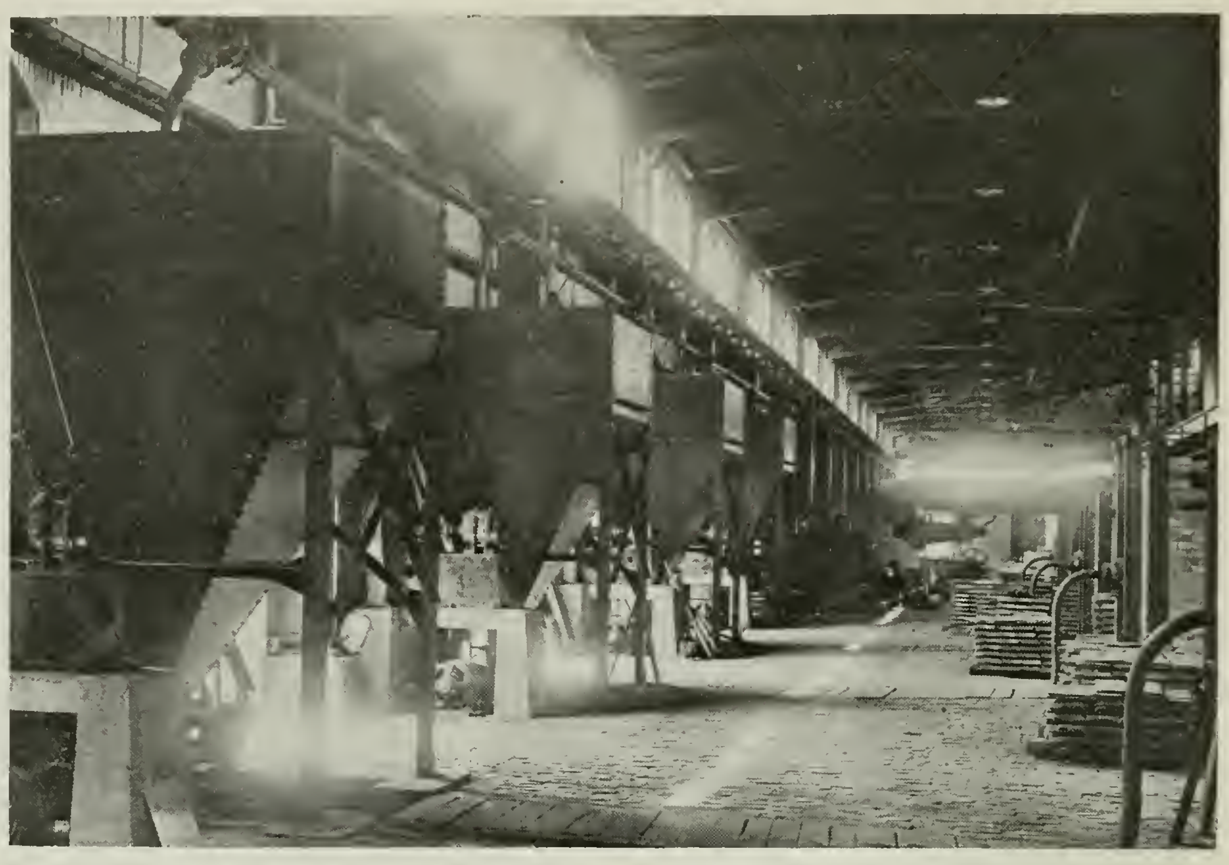


Fig. 4—Rear view of heating furnaces showing hoppers for powdered coal and feed lines to furnaces.

bins meet all fuel requirements both for steam power, for heating and annealing furnaces, and for galvanizing pots. No cyclone separators are used.

All coal unloading for the entire plant operation is concentrated at one point. Broad gauge cars dump into the coal elevator pit. From it, it is hoisted to overhead storage bins of ample capacity. From the Jeffrey single roll crusher and pan conveyors the coal goes to a magnetic separator, thence to rotary indirect pulverized coal-fired Fuller-Lehigh drier where moisture is extracted so that one percent or less remains, thence to pulverizers which reduce to approximately 85 per cent through 250 mesh, all through 100 mesh. The cost of this complete pulverizing installation was in the neighborhood of $125,000, but the plant economics are such that this expenditure is amply justified. Not the least interesting advantage which this installation possesses is its ability to utilize any grade of coal available at lowest cost. The plant is now operating on rejected coal, coal otherwise unsalable for steam railway or steamship uses, a supply of which is constantly available at Ashtabula.

Mill Engine.

The mill rolls are steam driven through a single set of pinions by a high Efficiency Nordberg Uniflow twin engine of 1500 hp. two cylinders 28 in. by 36 in. at 150 rpm—geared through Falk 5 to 1 reduction gears to a normal roll speed of 30 rpm. It is designed for a very flat load curve from 500 to 2000 hp. and a hand gear is provided for the purpose of backing off in cases of emergency. Fig. 2 gives an inadequate view of one side of this engine the reduction gears, steam headers and separators. In the foreground will be noticed the main roll shaft.

Hyde Park Sheet Mill.

The sheet mill itself located in the main span is divided into two balanced sections—one-half on each side of the drive — each comprising two roughing stands, four hot stands and two cold roll stands (16 stands in all) built by the Hyde Park Foundry & Machine Company. The special engineering feature of this department is in the housings, which weigh 19 tons and have a special screw box arrangement. They are arranged so that the usual upper part is eliminated. This is a decidedly advantageous arrangement because very often serious delays are caused when the upper part of the screw box breaks or separates from the lower part.

The combined capacity averages between 5,000 and 6,000 tons of finished sheets per month Unusual shearing facilities parallel these mills; six Hyde Park shears, motor driven, are now in operation together with one bar shear.

Two roller levelers take care of the blue annealed material.

Ample bar heating and sheet reheating capacity is provided through eight furnaces directly adjacent to the mill rolls.

Excellent crane service facilities rapid movements of production flow.

One Cleveland 30 ton crane with 10 ton auxiliary over the mills; one Cleveland 5 ton crane over the far bay; one Cleveland 10 ton crane over the furnace bay.

Fig. 4 shows the rear view of the heating furnaces with the hoppers for powdered coal and feed lines to furnaces.

Fig. 5 shows cooling racks in the foreground, annealing furnace in center and roll stands beyond.

The production of the mill flows in direct line from the squaring shears to the very large duplex annealing furnace.

Annealing Furnace.

The annealing furnace is a 12- car continuous double chamber under-fired recuperator type. In plan the furnace is divided into four sections. The sections comprise two annealing and two cooling chambers of three cars each. In operating, two cars are discharged simultaneously at certain intervals. Each half of the furnace is entirely independent of the other half and for this reason may be treated individually under operating conditions. The temperature of the compartments into which the cars first enter, is held uniform continuously. After the cars enter the cooling chambers, the temperature decreases as the cars approach the discharge end.

Recuperation or preheating of the air used for combustion is accomplished by passing it through conduits placed on continuations of the bridge walls in the cooling chamber and connecting with conduits in the stack flue, below the combustion chamber, in the annealing section. The air is subsequently mixed with the fuel in the burners.

The furnace is designed to utilize various forms of fuel, although in this instance pulverized coal is used exclusively.

One large bin divided into eight compartments is used for storing pulverized coal at the furnace. This bin is fitted with eight coal feeders, one for each burner on the furnace. Each coal feeder is direct connected to a variable speed motor through a speed regulator. Separate fans are provided for conveying the combustion air. The combination sheet and pair, galvanizing and boiler furnaces are similarly equipped.

The pickling tanks, washing machinery and all galvanizing equipment was manufactured by the United Engineering & Foundry Company.

A very interesting feature of the galvanizing operation is the design of the pot furnaces. These hot metal pots and their pulverized-fired furnaces are the only layout of the kind in the world. There are two spelter pots, one of 30 tons spelter capacity and one of 50 tons spelter capacity. The first has a production in galvanized sheets of approximately 30 tons per 24 hours and the second 60 tons per 24 hours. The galvanizing department is soon to be increased to six pots.

A varying proportion of the mill tonnage is finished through the corrugating rolls and the balance goes into commercial shipments as galvanized sheet or black sheet in all thickness from 1/80 to 9/65 of an inch thick and in sizes 40 in. wide by 144 in. in length. These sheets find their way into the manufacture of stove pipe, conductors troughs, metal ceilings, metal furniture, building sheets and roofs, automobile stock, etc.

Mill Buildings.

The mill main building shown in Fig. 7 is 624 ft. long by 166 ft. wide and is divided into three main spans, the main span is 66 ft. wide with two 50 ft. side

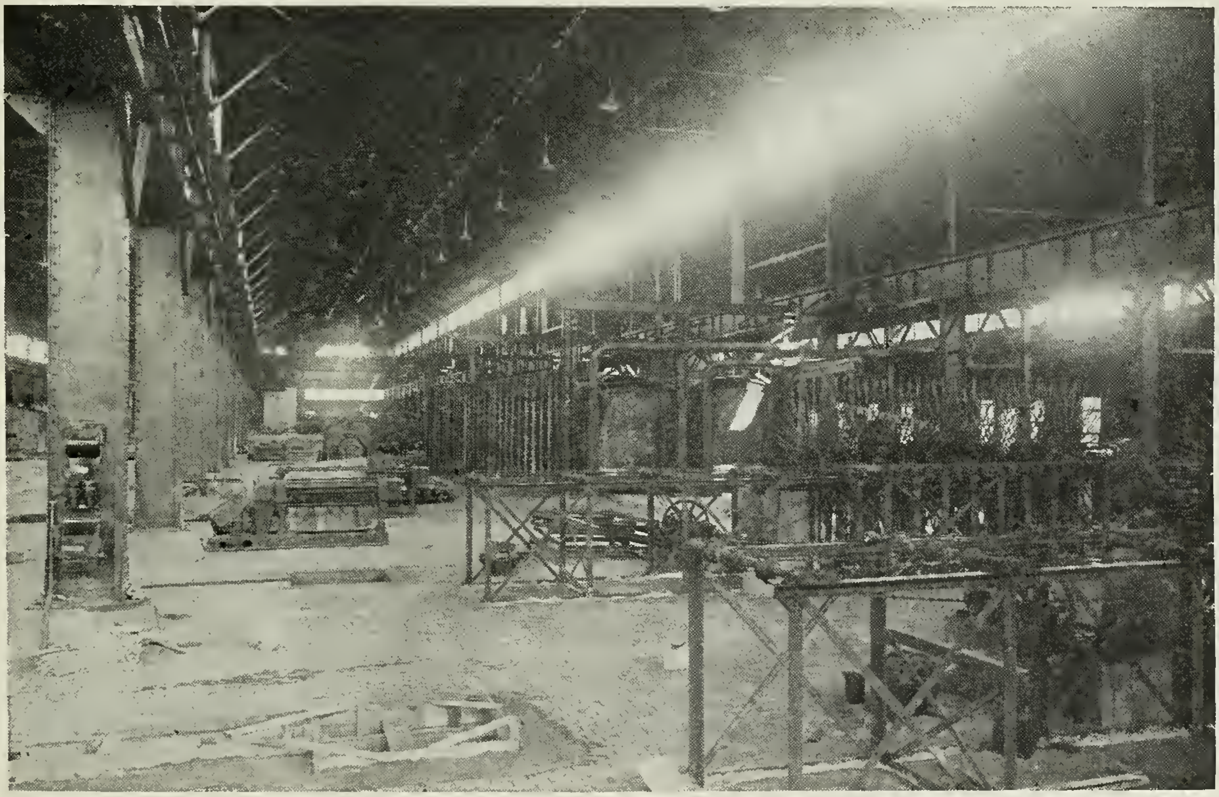


Fig. 5—Inside view of mill showing cooling racks in foreground, annealing furnaces in center and roll stands beyond the annealing furnaces.

spans. Built under contract by McClintic-Marshall Construction Company, it leaves nothing to be desired where comfort, accessibility and ventilation are considered. Because of the exceptional wind pressure noticeable in lake storms, the building is of high reinforced construction. The lighting arrangements are excellent—the result of a special study of sheet mill lighting requirements by Mr. McGaughey, the operating master-mechanic and electrical superintendent, who also designed and installed the entire electrical layout, switchboard and controls, which are a model of operating practicability.

Personnel.

Robert Lock, the President and General Manager of the Ashtabula Steel Company, is a man of wide experience in the sheet steel industry. He recently organized the highly successful Apollo Iron & Steel Company, designed the plant, and was largely responsible for its remarkably rapid development. E. H. Werner, associated with Mr. Lock as Chief Engineer in the design and construction of the plant, has many successful sheet mills as monuments to his genius and ability. The executive officers and operating officials are as follows:

H. M. Kunkle, treasurer; T. J. Rennick, secretary; E. J. Secrest, auditor; M. R. Gray, paymaster; W. J. Kunkle, assistant treasurer and purchasing agent; Severn P. Ker, sales manager; W. M. Hannum, chief clerk; C. W. Johnson, order department, and H. C. McGauhey, master mechanic.

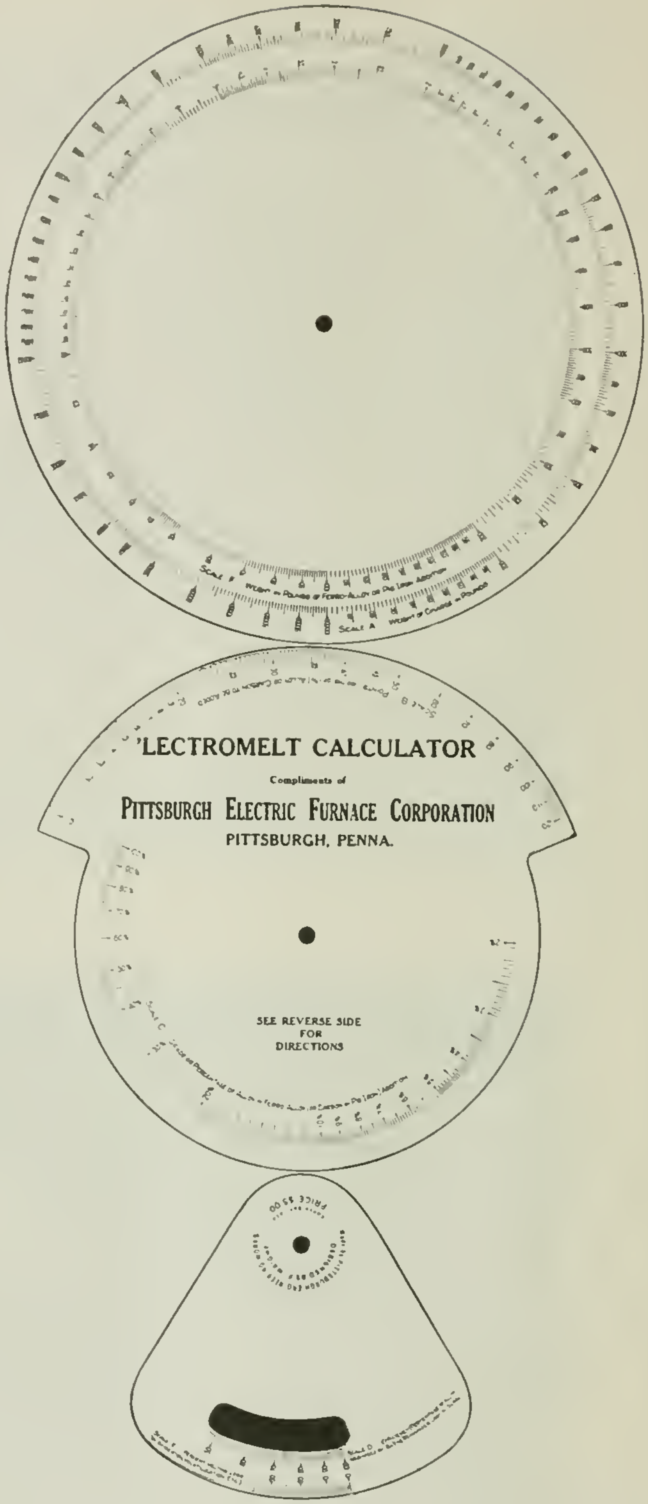
SLIDE RULE FOR CALCULATING ALLOY ADDITIONS

The Pittsburgh Electric Furnace Corporation, Pittsburgh, Pa., has developed a circular slide rule for calculating weight of alloys to be added in making various alloy steels. It is called the 'lectro melt calculator and is made from three celluloid discs as shown above. A replicate similar to the one which they are circulating, but somewhat smaller, may be made by mounting the above figures on cardboard, cutting out according to the outlines and the black oval in the lower figure, then pinning through the black dot. This device may be used by the furnace superintendent and melter in figuring mixtures and in allowing for ordinary percentages of loss in the absorption of the alloy in melting. The instructions which appear on the back of this slide rule are shown below:

Directions—Over the weight of the charge on Scale A set the number of points of alloy to be added on Scale B, holding these points together, over the grade or percentage of alloy in the ferro-alloy on Scale C, set the efficiency of absorption of the alloy on Scale D. Under the per cent of melting loss on Scale E, read the number of pounds of ferro-alloy required.

Example—Assume charge of 6,135 pounds. Assume necessary to add 14 points (.14 per cent) to bath, using 80 per cent ferro-manganese at 85 per cent efficiency of absorption and melting loss of 3 per cent in bath.

Calculation—1. Set figure .14 on Scale B over 6,135 on Scale A. 2. Set 85 per cent on Scale D over 80 per cent on Scale C. 3. Read opposite 3 per cent on Scale E alloy addition on Scale F, 12.3 lbs.



Scale A
'LECTROMELT CALCULATOR
Compliments of
PITTSBURGH ELECTRIC FURNACE CORPORATION
PITTSBURGH, PENNA.
SEE REVERSE SIDE FOR DIRECTIONS
PRICE

Circular slide rule for calculating alloy additions. Mount on cardboard and cut out. Cut out black oval and pivot through dots. Instructions for use of same are found in column opposite.

INDIANS PLANNING IRON EXPANSION

The largest iron and steel interests in India, the Tata Iron and Steel Works, are planning, according to reports received by the Department of Commerce, to enlarge their capacity by the end of 1923 to an output of 650,000 tons of pig iron and 425,000 tons of finished steel annually, a large increase over their present capacity of approximately 300,000 tons of pig iron and 125,000 tons of finished steel.

The Thermal Efficiency and Heat Balance of an Open Hearth Furnace*

Results of Investigation of Great Economic Value—Discussion of Gas and Air Ports—Comparison of Earlier Furnace Designs with Present—Waste Heat Recovery Through Steam Generation.

By C. L. KINNEY, JR.,† and G. R. McDERMOTT‡

BEFORE disclosing the subject matter of this paper, and in view of the economic significance of the subject involved, the authors' desire to present the following facts and suggestions for consideration by the members of the Institute.

The independent investigator of open-hearth furnace efficiency, in planning such work, is immediately confronted by the question of, not only what shall be observed and recorded, and of methods and interpretation of such observations, but also by questions of correctness of the values used in the calculations.

He also has to determine a scheme of tabulation of the data obtained, in such a form that the conclusion drawn shall make an emphatic appeal to those in charge of open-hearth plants and thus excite a larger interest in this important matter.

Considering the magnitude of the industry, there exist but few complete investigations of the subject, and practically all those published differ widely both in final form and in the thermo-chemical and therom-physical values used. It seems obvious to us that there exists a very great and important need that all work of this character should be carried on by standardized methods, values, and forms, which would make comparisons of results possible. It also seems evident to us that the adoption of such a code would do much toward awakening a greater interest in this matter, which would certainly be reflected by pronounced economies in the industry. We therefore suggest that, representing, as it does, the iron and steel industry of this country, it lies specifically within the jurisdiction of the Iron and Steel Institute to appoint a committee to prepare and sanction some such standard method of determining the thermal efficiency and heat balance of the open-hearth furnace, and we further suggest that those members, who manage such plants, pledge themselves to use in such investigations the standard method authorized by the committee. It is distinctly without our province to make specific recommendations concerning this code, but we feel that the method used by Mr. Fred Clements in his excellent paper on this subject, which appears in the Journal of the Iron and Steel Institute (London), 1922, Vol. CV, p. 429, is the most simple and practical of any extant, and for this reason we have in our presentation very largely followed his plan.

The purpose of this particular investigation was to determine the present efficiency and heat balance of a typical open-hearth furnace as operated at these works and to show what improvements have been made and wherein the losses shown may be minimized. With this in mind we show a design of a 100-ton furnace in which are embodied certain improvements revealed in the following text.

Regenerators.

The proposed 100-ton furnace, as will be noted, has been provided with insulated checker chamber walls only, but no increase of combustion chamber efficiency has been assumed. While it is unquestionably true that an increase in checker chamber temperature is followed by increased combustion temperatures in the melting chamber, we do not feel warranted with the data available in making a specific increase in melting chamber efficiency, but are satisfied to show that the heat conserved by this insulation is of advantage in our waste heat boiler only. It may be asked why the checker chamber roofs are not so insulated, thus further conserving heat. To this question we will reply by saying that the peak temperature in these chambers is at present not far below the softening temperature of fire-brick and it is felt that any great increase would involve chamber roof collapse.

In an open-hearth furnace the two main features which make its operation possible are the regenerative chambers and a port arrangement, capable of producing a high temperature flame within the melting chamber.

The fundamental principles involved in regeneration of heat, by means of checker work, have been so many times stated, that a repetition of them is not considered necessary. It unfortunately is true that too many open-hearth furnaces are operating with checker work which in part only uses these basic theories, and in consequence their efficiency is low.

It should be borne in mind in designing checker work and chambers that to merely remove from the outgoing gases a very large proportion of their sensible heat does not mean high efficiency in the melting chamber, because the production of a high temperature fuel column is in part a function of high temperature incoming air and gas, and such temperatures cannot be reached if the sensible heat of the waste gases is dispersed over too great an area. From this it is obvious that the most efficient checker must have in its upper section the maximum concentration or intensity of heat that will permit incoming gas and air to reach the ports at the highest possible temperature and at the same time in the bottom section to discharge the waste gases at a low temperature. A strict application of the foregoing principle would of necessity lead one to design a deep checker chamber of small horizontal cross section and the checker work itself with very small flues; for it is also a fundamental principle in heat transfer of this nature that the highest efficiency is obtained the more nearly we can approach the critical velocity of the gas used.

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*Paper read before American Iron and Steel Institute, New York City, October 7, 1922.

†Superintendent No. 1 Open Hearth Department, South Works, Illinois Steel Company, South Chicago.

‡Assistant Chief Engineer, South Works, Illinois Steel Company, South Chicago.

The commercial as opposed to the purely technical aspect of the deep checker work and small flue are as follows: The deep chamber involves an increase in charging floor height, if ground water is to be avoided, which adds to building cost and in addition consumes, in the form of energy necessary to put up on the charging floor the raw material for steel making, probably more fuel than is saved; nor can there be any question of the added labor cost involved in the removal and replacement of such checker work. The very small flue area is objectionable from a practical standpoint, because in its upper sections it rapidly becomes clogged with oxides, and thus the efficient campaign of a furnace is reduced to an uneconomical extent. One is thus forced in the practical design of checker chamber and checker work to sacrifice a certain amount of theoretical efficiency, which is more than compensated for in the form of practical gain. The checker work shown in our drawing of the 1922 and 100-ton furnaces was designed to give the greatest possible inlet area (number of top openings per square foot of horizontal area) and the maximum square feet of exposed surface per cubic foot of checker brick, but also, in its individual flue area of thirty-six (36) square inches, gives a velocity high enough for a very excellent rate of heat transfer without premature clogging and consequent suspension of efficient operation. Thus, based upon local conditions and results obtained over an eight-year period, we feel that this practical compromise with theoretical considerations represents for us the best available type, and so have used it in the 100-ton furnace. Specifically the net gain in efficiency represented by this checker work and expressed in actual pounds of coal per ton of ingots is as follows: Period of 1912, with checkers shown in Fig. 1 and burning Universal mine run coal, which has an average proximate analysis as follows: Volatile, 35 per cent; fixed carbon, 45 per cent; ash, 8 per cent; moisture, 12 per cent; Btu., 11,445, the average coal per ton of ingots produced was 750 pounds, and over an equally long period during 1914, using the improved checker work and the same coal, the pounds per ton of ingots was reduced to 684, a decrease of 8.8 per cent. Had we been using, during the periods named, what may be termed a standard gas producer coal of high fixed carbon, low ash and moisture content, having a heat value of 13,400 Btu., our coal per ton of ingots would have been for the 1912 period, 600 pounds and for the 1914 period, 548 pounds, this last figure representing actual results. It should be unnecessary to mention the desirability of the proper arrangement and size of flues under the checker work, and in the design shown we have attempted to minimize short-circuiting by progressive increase in area from bridge-wall to valve flue, at the same time keeping ample area in all parts in order to take care of deposited oxides. Ample insulated flue area, between regenerative chamber and valves and boiler, has also been provided.

Gas and Air Ports.

The area of gas port, or ports, is determined by the proper velocity of gas used This area varies with the character of the gas; a low Btu. gas having a high hydrogen and water vapor content and consequently a larger volume per unit of heat, naturally requires more area than a gas made from a better coal.

The air port area is in proportion to the theoretical air necessary to burn the gas plus a certain minimum excess. The location of the bottom of the gas port should be high enough to prevent partially unburned gas from coming in immediate contact with the bath, thereby delaying combustion. It should be noted in this connection that the modern furnace by providing a combustion space for the incoming gas is in marked contrast in this respect (delayed combustion) to some older types. Yet today it is not unusual to finl furnaces, the face of whose gas ports are too far advanced into the melting chamber and the bottoms of the ports not high enough above the bath level. Inspection of an empty bottom, where such an arrangement of gas port is used, reveals the end banks extending an abnormal distance into the crucible (bath space). The antithesis of such a condition prevails where gas ports are set too far back, thus causing a very high temperature flame to play upon the pass over the end banks. With this condition these banks will soften and cut instead of building out and trouble will be encountered in the form of delays in repairing them, and in the loss of heats.

The correct proportioning of gas and air ports and their relative locations, etc., are based, fundamentally, upon a desire to obtain the most intimate mixture of the two gases as quickly as possible. However, the problem is further complicated by the necessity of directing the intensely hot flame thus produced so that in its relation to bath surface, it shall give up heat mainly by conduction and at the same time be kept away from the side walls and roof of the melting chamber. In the later type of furnace, the gas ports have been so placed that the so-called flame temperature of the stream of entering gas is not reduced by immediate contact with the bath to a point which inhibits an efficient further flame propagation. Having thus provided a hotter fuel column, it follows that provision must be made for its proper direction. Mere increase in velocity at or adjacent to the point of preliminary combustion is inadequate and it is thus necessary to resort to a reduction of area well in advance of this zone to prevent velocity dispersion and an uncontrollable fuel column. Reference to Fig. 1 Port End will show that in this early type of furnace, while a preliminary combustion zone existed, there was a decided lack of contact area between incoming gas and air. A cross section of the combustion chamber at the gas port mouth shows that only the upper portion of the producer gas column is in contact with the air column. Fig. 2 shows how this area of contact has been increased by the admission of air on the sides of the gas port.

Referring again to Fig. 1, it will be noted that, after leaving the zone referred to in the preceding paragraph, the area of greatest confinement was 43 square feet, and the continuity of direction and compactness of the fuel column was largely a matter of velocities and confinement in the zone immediately adjacent to the gas port mouth. Any attempt to increase fuel and air contact areas by adopting the plan of preliminary combustion, while maintaining 43 square feet as the area of greatest confinement, would have been followed, perhaps by better flame propagation, but certainly by a high temperature fuel column, which lacking direction, would have unquestionably destroyed the roof and side walls in the course of a short campaign.

To maintain the proper direction and compactness of the fuel column under the 1922 condition of preliminary combustion, it was necessary to prevent velocity dispersion, by decreasing the area of confinement to 20 square feet, which is practically the amount indicated by the increased volume of the gases, due to their temperature increase between the face of the entering port and the point of greatest confinement. Not only does this decrease in area (23 square feet) result in a regular compact fuel column, but by increasing the intimacy of the mixture of gas and air an improvement in combustion is attained. Such reduction in area does not, as might be supposed, affect the efficient removal of the products of combustion from the melting chamber. With a furnace of this type, there exists, however, a limit in the input energy in the form of gas, lower it is true than in the 1912 type, but by no means the ultimate. In all probability this limit is a function of the amount of air capable of being delivered to the melting chamber by the stack effect of uptakes and checkers, against the melting chamber pressure. The ideal furnace must retain those features which promote partial and complete combustion, compactness and direction of the fuel column, but should in addition make possible a greater energy input per unit of time, which by speeding up the process reduces heavy radiation losses per unit of fuel fired.

The 100-ton furnace not only increases intimacy of mixture for the necessary combustion, and the confinement of area necessary for efficient control of the flame, but in addition provides an outlet area capable of handling a greater input enegry.

Slag Pockets.

Size should be such that the furnace campaign will not be shortened by premature filling. This rate of filling varies with the completeness of the combustion of fuel, character of charge, degree of permissible water-cooling and refractoriness of the brick. Air-cooling of division walls minimizes gas leakage. Air-cooling of wall between slag pocket and checker chamber reduces the danger of slag breaking through and clogging checkers and flues. Air-cooling of the bottom produces a physical change in the deposited slag which facilitates its removal.

The 100-ton furnace shows the air-cooling system connected to a fan which supplies air to the furnace. This arrangement increases circulation and renders cooling more efficient and adds sensible heat to the incoming air.

The 100-ton furnace shows a substitution of the damper type valve for the rotating water-cooled type and while there is no question of the superiority of the former due to its easier flow lines, there is also much less heat lost in the cooling-water and the absence of water vapor carried into the furnace from the exposed water of the seal. It is also thought unadvisable to attempt to show a specific increase in combustion chamber efficiency from such an improvement. It should be emphasized, however, that a valve of this type, used on the air flues, eliminates the short-circuiting of a larger or smaller portion of the incoming air to the stack flue, which in the butterfly type comes from faulty sealing of the valve tongue and entails losses more serious than commonly supposed.

Water Cooling.

The amount of useful energy which is absorbed from the furnace system by water-cooling devices has been and is a subject of polemic rather than practical discussion. In making a decision whether or not to water-cool, both commercial advantages and thermal loss should be carefully weighed, the one against the other. Consider, for example, the water-cooling of a gas port. It is granted without discussion that the highest possible temperature in the burning fuel column is a function of the temperature of the incoming gas and air, and that any absorption of heat will be followed by a diminished flame temperature and a consequent loss of efficiency. There is, however, another factor of prime importance in efficient open-hearth furnace operation, which has been mentioned in that section of the paper dealing with port construction, namely, flame control and direction, and its importance to heat transfer to the bath and the maintenance of brick-work. It seems obvious to us, while a dry port will produce a slightly higher flame temperature over a short life, that the time lost in repairs and the inefficiency of and damage done by a poorly controlled flame, before repairs are made, actually produces a far greater commercial loss than the slight reduction in flame temperature from a proper amount of water-cooling. Considerations of this character based on experience, have led us to adopt the cooling devices shown in the 1922 and the 100-ton furnace.

Waste Heat Boiler.

The waste gases from metallurgical furnaces, particularly those issuing from the open-hearth, present an excellent opportunity for utilization in steam generation by means of a waste heat boiler.

The first studies and installation of a waste heat boiler in connection with an open-hearth furnace were made at the Illinois Steel Company, South Chicago, during the year 1910 and upon the results then obtained have been based the rapid development and applications of the modern waste heat boiler.

The sensible heat in the gases after passing through the regenerators of an open-hearth furnace represent 30 to 50 per cent of the heat available in the fuel as fired.

The absorption of the heat content of these gases is largely obtained by convection which necessitates the travel of the gases at high velocity over the heating surface of the boiler. Consideration of the formula governing this phenomenon will develop the reason.

The rate of heat transfer for either fire-tube or water-tube boilers may be expressed in the formula:

$$R = \frac{H}{T-t} = a + b\frac{W}{A}$$

R = heat transfer rate in Btu. per hour per square foot of heating surface per degree F. difference in temperature.

H = Btu. transferred per hour per square foot.

a and b = constants.

$\frac{W}{A}$ = Mass velocity expressed as pounds of gas per hour per square foot of area of gas passage.

In order to absorb by convection, the molecules of the flowing gases come in contact with the heating surface of the boiler and impart their heat to it. The rate at which the heat is imparted to a unit surface

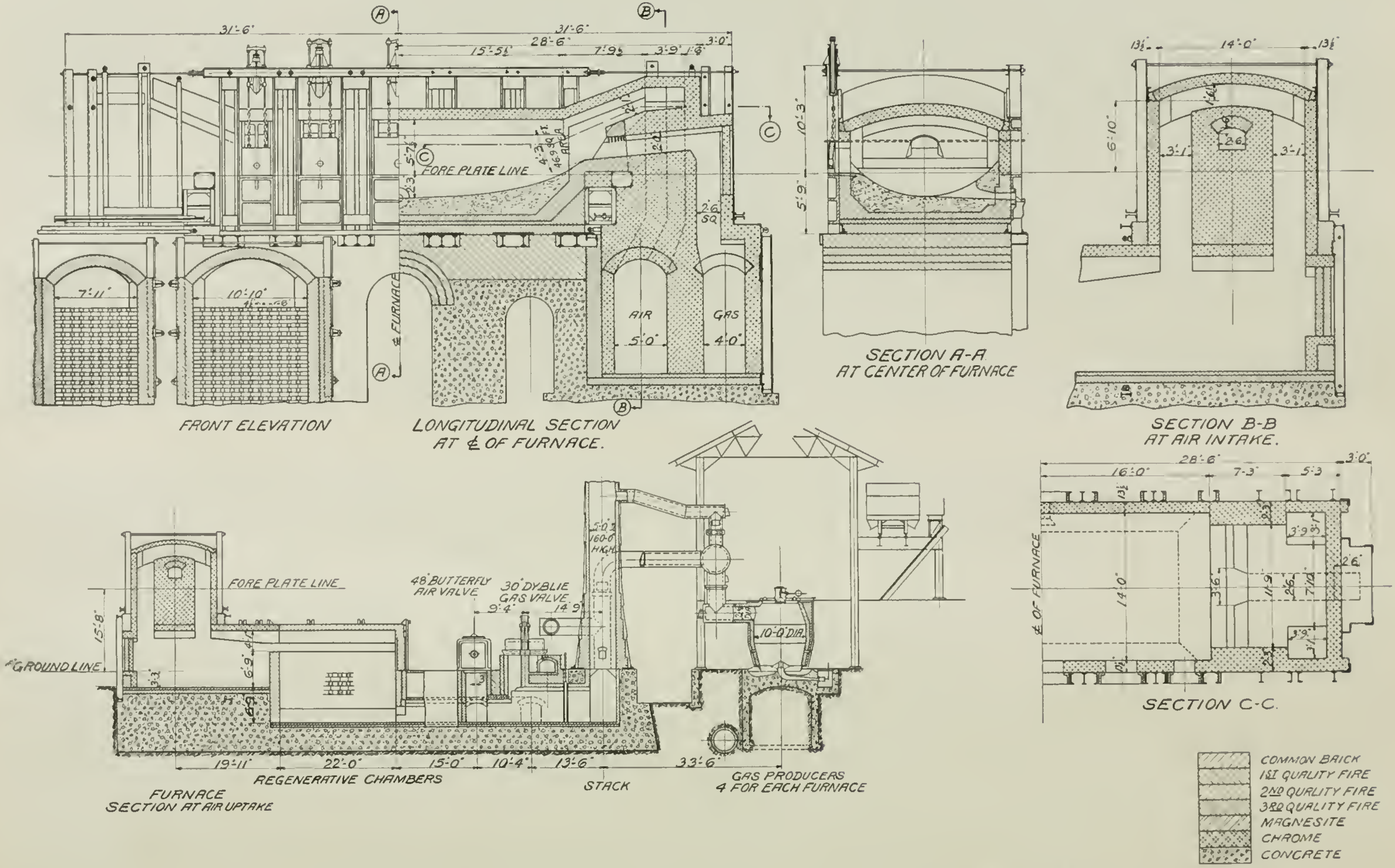


Fig. 1—Typical open hearth furnace of the period 1912, South Works, Illinois Steel Company.

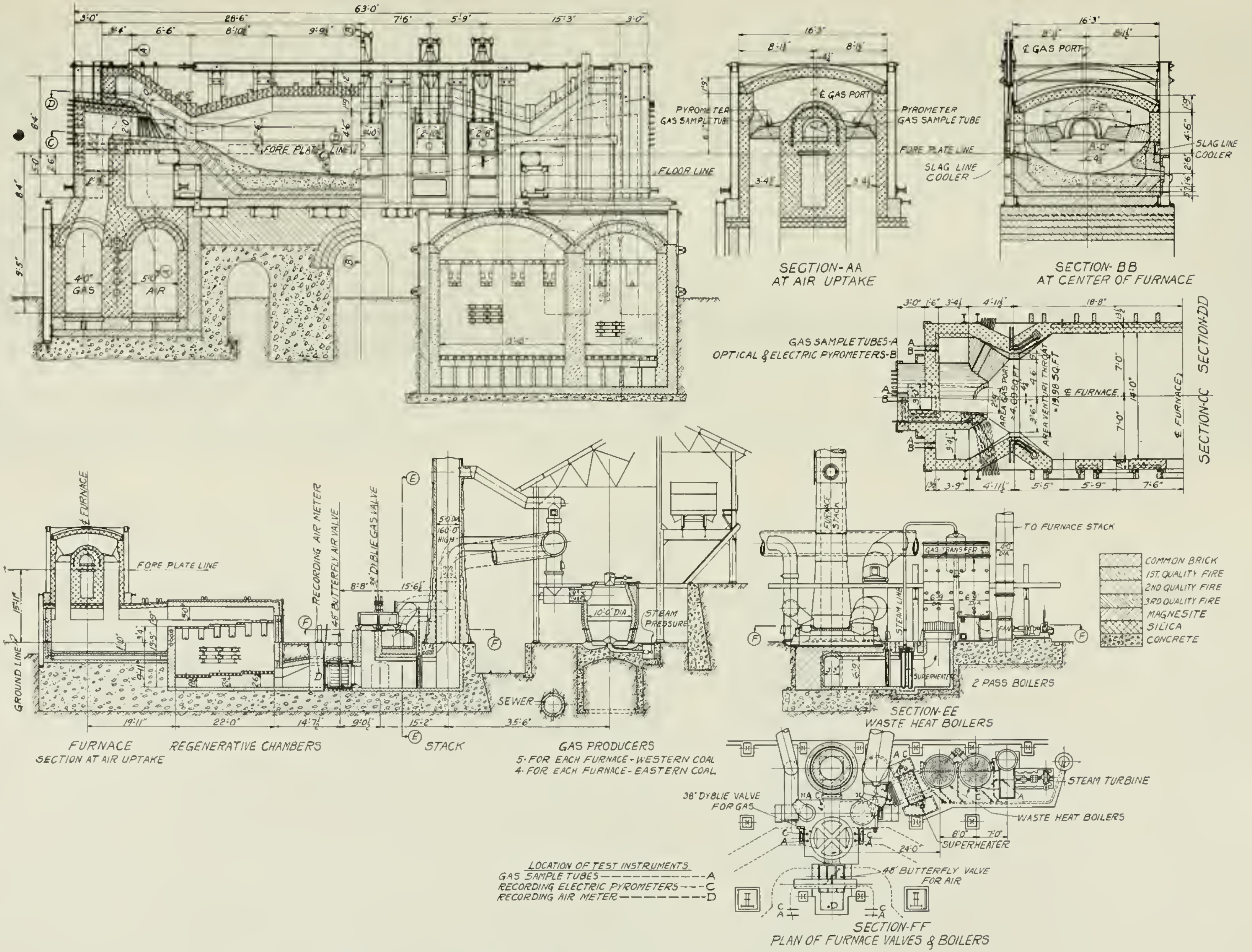


Fig. 2—Typical open hearth furnace of the period 1922, South Works, Illinois Steel Company.

depends, therefore, on the number of gas molecules coming in contact with it per unit of time.

By referring to the above equation of "R" for different tube diameters, it will be noted that the value of "R" not only increases with the reduction in diameter of the flue, but also with an increase in the ratio of $\frac{W}{A}$, mass velocity. This absorption phenomenon manifests itself to a greater degree when the gases are at or above their critical velocity.

The above phenomena and advantages also apply to economizers. During the past year, three fire-tube type of waste heat boilers, equipped with fire-tube economizers, were installed in connection with open-hearth furnaces, and the results obtained from both boilers and economizers further confirmed the theory outlined above.

By referring to Fig. 3 it will be noted that a fire-tube type of boiler and economizer is shown, of sufficient size to handle the waste gases leaving a 100-ton furnace. Both the boiler and economizer are constructed with 3-inch diameter flues.

The reduction of space required, lower first cost, less draft loss, elimination of air leakage due to infiltration, and ease of maintaining a clean surface on the gas side of the heating surface for equal evaporation lead to the adoption and installation of the fire-tube type of waste heat boiler at South Chicago in 1915 and in 1917.

In order to illustrate, by comparison, what may be accomplished for equal output by a boiler constructed with 2-inch diameter flues as a means of reducing the first cost and space requirements, a separate outline is shown on the same sheet of such a boiler and economizer. It is the belief of the authors that no difficulty will be encountered by the use of the 2-inch flues due to accumulation of dust in them. The relatively high velocity of the gases through the flues will tend to keep them clean; dust accumulation to any extent will be at the entrance of the flues on the bottom of the boiler. This dust can be readily removed periodically as the occasion arises.

The square feet of heating surface of the boiler and economizer constructed with 3-inch flues is 6250 and 2200 square feet respectively, while the square feet of heating surface of the boiler constructed with 2-inch flues and an economizer having 3-inch flues is 3100 and 2200 respectively. The latter installation would consume more fan power on account of the greater friction loss through the 2-inch flues as compared with the 3-inch flue. The cost of this power would be offset by the difference in first cost of the installation and interest on the investment.

Attention is called to the table compiled and shown in Fig. 7 which gives the "Overall Thermal Efficiency of the Utilization of the Coal Burned" in operating an open-hearth furnace with and without a waste heat boiler. The furnace equipped with a waste heat boiler utilizes as useful work 35.9 per cent of the energy in the coal fired at the producers, as compared to 16.1 per cent with the furnace not so equipped. This difference would be further increased by the installation of an economizer.

Gas House.

A modern gas producer plant has been shown, in which are provided mechanical producers, large insulated gas mains and a covered coal storage. Four 10-foot mechanical gas producers are provided, with top poking and leveling apparatus, bottom agitation, ash removal and disposal. The peak gasification thus provided for using a mine run coal of the following natural proximate analysis (volatile, 35 per cent; fixed carbon, 44 per cent; ash, 8 per cent; moisture, 13 per cent), is approximately 27 pounds per square foot of effective grate area per hour, which is well within the limits of efficient continuous operation of a modern producer. It is true, that if a better grade of coal were used the capacity provided is excessive, yet if consideration be given to the gradually decreasing quality of gas coals and the irregularity of the coal mining industry, it was felt justifiable to provide an ample margin of safety in gasification rates. The enclosing of the coal storage bin is shown and recommended on the basis of thermal losses arising from excess extraneous water in the fuel.

Thermal Efficiency and Heat Balance Test.

In order to collect and observe the required data to confirm the soundness of the before outlined theories pertaining to regeneration and combustion, it was necessary to determine the thermal efficiency of a furnace designed along the lines of these theories and compare by the same method the performance of a furnace not embodying the principles as outlined. In addition to the determination of the thermal efficiency a "heat balance" was made to show the distribution of the thermal energy, from which further changes may be made leading to greater economies.

To collect the basic data, observations were made on three successive heats on Furnace No. 24 at Open-Hearth No. 2, South Works, Illinois Steel Company, which we considered was approximately at a point in its campaign representative of normal furnace conditions. On account of the necessity of calibrating the instruments and co-ordinating the efforts of the personnel engaged in observing and recording the required information, the results of the observations taken on the first two heats were considered only as preparatory work.

During the test a detailed log was kept of the furnace charge and operation. The weight of the coal fired in the five gas producers was accurately weighed and sampled. Both incoming charge and the product, in which were included ingot butts and scrap on the pit side and all slag, were carefully weighed and sampled. The furnace crucible (bottom) was practically free from slag and metal both at the beginning and end of the test heat.

All pyrometers were calibrated before the test at the company's pyrometer laboratory. During the test the pyrometers measuring the temperature of the ingoing and outgoing gases were checked by an optical pyrometer sighted on silica and fire brick closed tubes which projected into the path of the gases.

A large orifice was installed in a 42-inch air duct leading to the air valve of the furnace. A very sensitive and accurate air meter which recorded the differential pressure accross the orifice was loaned us through the courtesy of The Bailey Meter Company of Cleveland, Ohio.

Conclusion.

In the preceding text we have dealt to a large extent with such theoretical and general considerations as seemed to us supremely important in open-hearth furnace design and operation. Such important matters as fuels, gas producer design and operation, slags and the relative value of different processes and their effects upon efficiency, necessarily remain untouched.

Fig. 3 is a graphic record of the principle temperatures, air flow to furnace and coal log covering the period from tap to tap.

The heat balance shows a total heat input of 531 million Btu. in the coal fired in the gas producers, of which 493 million Btu. was delivered to the furnace gas valve, no allowance being made for the tarry vapor content of the gas.

Of this 531 million Btu., the principle losses were:

Losses	Millions of Btu.	Loss in Per Cent of Coal Fired
Carbon monoxide in waste gas sampled at port ends	53.5	10.01
Heat radiated from checker chambers, slag pockets and uptakes	38.8	7.3
Total heat absorbed by cooling-water (not including gas valve)	71.75	13.5
Heat absorbed by gas valve	10.75	2.0
Heat in waste gas to boiler	270.00	51.0

The heat in useful work in the steel produced amounted to 85.29 million Btu. or 16.1 per cent of the Btu. contained in the coal fired. The net heat recovered by the waste heat boiler, after deducting the heat in the steam used for blowing the five gas producers was 87 million Btu. or 16.4 per cent of the Btu. in the coal. The large losses in cooling-water have been discussed in a preceding part of the paper.

The apparent loss in the form of unburned carbon monoxide is in part recovered by secondary combustion in the checker chamber and largely appears as additional heat in the waste gases utilized by the boiler. This large loss to the furnace is uneconomical from the standpoint of furnace efficiency, and may be corrected in a large measure by improving melting chamber combustion.

Some 38.8 million Btu. are lost by radiation from checker chambers, slag pockets and uptakes, and we would expect in the 100-ton furnace to prevent a portion of this by insulation of the checker chamber walls.

The gases leaving the waste heat boiler can be further utilized by means of a feed water economizer to the extent of approximately 8 per cent additional steam generation, as demonstrated by a recent installation at these works.

In detail data of the efficiency of two different types of furnaces it will be noted that two thermal efficiencies are shown, the higher representing bath efficiency based upon the fact that, by oxidation, the carbon content of the bath is reduced to carbon monoxide and contributes heat to the bath by such a thermo-chemical reaction. The lower efficiency figure is based upon the belief, that the carbon monoxide thus produced, after escaping from the bath, should in a large measure be burned in the melting chamber. Upon this basis, we feel justified in assuming that if the major portion of carbon monoxide so produced is not burned in the melting chamber, it indicates defective combustion and naturally a reduced efficiency. For these reasons, we have charged against the furnace in the low efficiency figure the equivalent energy in the carbon monoxide if burned to carbon dioxide.

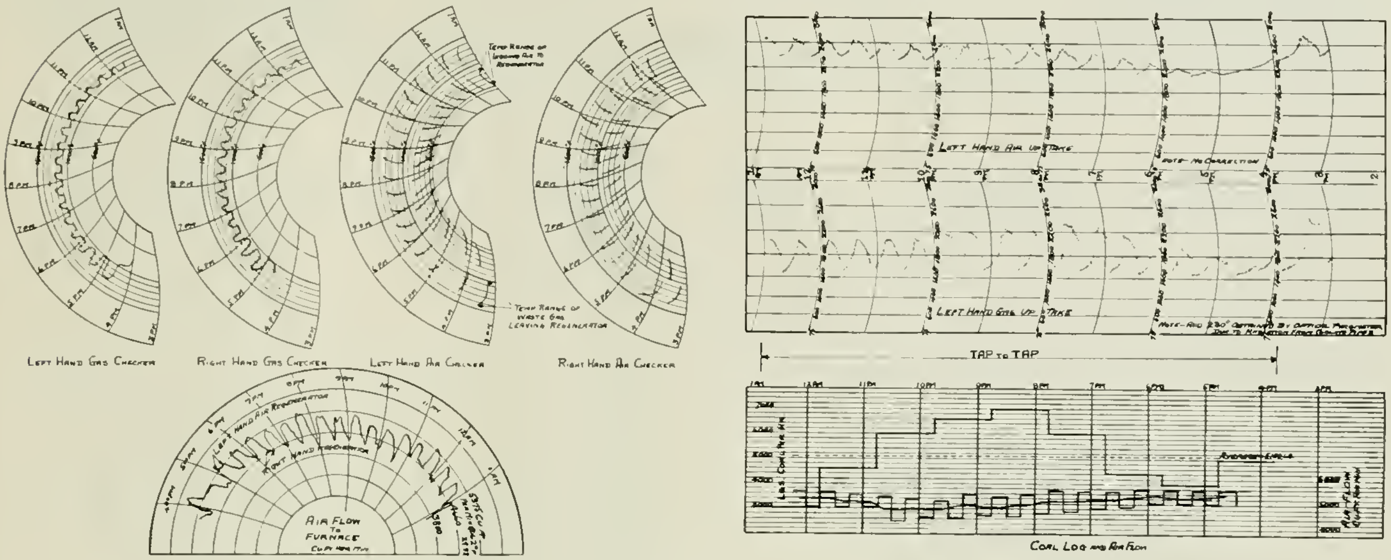


Fig. 8—Graphs of temperature, coal consumption and air flow, Heat No. 24565, September 26, 1922.

Referring again to Fig. 3, it will be noted, that the air flow as registered by meter indicated unequal air delivery to the opposed air chambers to the extent of approximately 20 per cent; and in addition failed to show any increase in the air input over those periods during which the greatest amount of coal was fired and the maximum volume of carbon monoxide was being evolved by the bath reactions. But what is more striking, the recorded air flow shows a reduction in the air delivered during those previously named periods, persumably due to a lack of stack capacity on the outgoing end of the combustion chamber. In the 100-ton furnace an attempt is made to partially overcome this deficiency, by increasing the outlet area of the melting chamber approximately 100 per cent, through the raising of a damper at this point.

To further an increase of efficiency in this respect, we propose to install a fan or other mechanical means of delivering air, and which is automatically controlled to supply air for effective combustion. The automatic control feature will supply air in proportion to the fuel consumed. This air control will operate in combination with an automatic control of the removal of the waste gases which must maintain a balanced draft in the melting chamber.

The need of providing a means of supplying the proper amount of air for combustion as demanded is emphatically shown by the ratio of fuel burned. It is apparent from the analysis of the waste gases and the record of the air flow meter, Fig. 3, that the stack effect of the air regenerators and uptakes cannot be depended upon at all times to supply the required air for efficient combustion. Needless to say this condition will exist regardless of the means employed for mixing the two gases before combustion takes place, although it is of course necessary to produce an intimate mixture of the two gases as well in order to obtain efficient combustion.

The following table gives a comparison of the important dimensions of the three types of furnaces discussed; and as a matter of additional interest we show the same data for the 100-ton furnace designed by Mr. Fred Clements of Rotherham, England.

The utility of a theory or theories can in general be said to be proven, or not proven, by the commercial result of their application over long periods of time; and we submit the following figures of pounds of coal per ton of ingots produced at these works during the periods covered by the text, as further proof of the soundness of the theories advanced.

UNIVERSAL NO. 4 MINE RUN COAL

Btu. per pound by calorimeter = 11,445

Proximate Analysis (natural) per cent.

Volatile	Fixed Carbon	Ash	Moisture	Sulphur
35.35	44.50	7.60	12.55	1.54

Period of 1912, pounds of coal per ton of ingots = 750.

Period of 1914, subsequent to improvement in checker work, pounds of coal ton of ingots = 684.

Period of 1922, subsequent to improved port and melting chamber design, pounds of coal per ton of ingots = 596.

Had the works been fortunate enough to have been supplied at all the periods named with what may be termed a standard gas coal, the pounds of coal per ton of ingots would be shown in the following figures which are confirmed by the actual operating results obtained during fairly long periods, when we were supplied with such coal.

LYNCH MINE RUN COAL

Btu. per pound calorimeter = 14,000

Proximate Analysis (natural) per cent.

Volatile	Fixed Carbon	Ash	Moisture	Sulphur
36.65	56.45	4.25	2.65	0.54

Period of 1912 = 600 pounds
Period of 1914 = 548 pounds
Period of 1922 = 477 pounds

In closing it is desired to express our appreciation of the care and interest taken by all participants in this work, both in observation, tabulation and drawings.

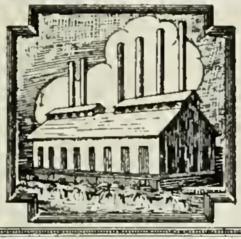
NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

The exposition covers the field of power and mechanical engineering from the moment the coal is taken from the ground until the power is turned into work in the final machine. Not only will there be representatives of prime movers and steam generating devices but also exhibits of manufacturers who have devoted their efforts to the solution of the troublesome problems involved in burning fuel and making and using power, whatever the industry requiring the heat and power derived.

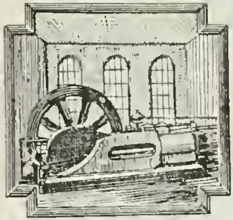
The educational value of the exposition will be heightened by a series of models showing developments of large central power stations from the old Pearl street station, the first in this country, to the present Hell Gate station. Each of the exhibitors is planning to have apparatus shown in motion or diagram which will enable the fundamental principles to be easily discovered.

A list of exhibitors (to date) who will exhibit at the National Exposition of Power and Mechanical Engineering, Grand Central Palace, December 7 to 13:

Allen-Sherman-Hoff Co.
American Arch Co.
American Refractories Co.
American Society Mechanical Engineers
American Steam Gauge and Valve Co.
Ashton Valve Co.
Bailey Meter Co.
Baker, R. & L., New York Corp.
Beaumont, R. H., Co.
Bernitz Furnace Appliance Co.
Bethlehem Shipbuilding Corp., Ltd.
Bishop & Babcock
Boig & Hill
Bowser, S. F., & Co.
Burhorn, Edwin Co.
Carling Turbine Blower Co.
Carlyle-Johnson Machine Co.
Cash, A. W., Co.
Celite Products Co.
Cochrane Corp., H. S. B. W.
"Combustion"
Combustion Engineering Corp.
Connelly, D., Boiler Co.
Connery & Co., Inc.
Coppus Engineering & Equipment Co.
Craig Damper Regulator Co.
Crane Co.
Davidson, M. T., Co.
Dearborn Chemical Co.
DeLaval Separator Co.
DeLaval Steam Turbine Co.
Detrick, M. H., Co.
d'Este, Julian, Co.
Diamond Power Specialty Co.
Drake Non-Clinkering Furnace Block Co.
Edward Valve Mfg. Co.
Ellison, Lewis C.
Engineer Co., The
Erdman Forced Draft Burner Co.
Falls Engine Stop Co.
Flinn & Emerich
Foster Engineering Co.
Foxboro Co.
Frederick Iron & Steel Co.
Furnace Engineering Co.
Gibby Engineering Co.
Gillis-Geoghegan, Inc.
Graver Corp.
Green Engineering Co.
Griscom-Russell Co.
Harris, Burt
Hays, J. W., Co., Inc.
Hill Clutch Co.
Huber-Hand Stoker Co.
Hunt, C. W., Inc.
Huyette Co., Paul B.
"Industrial Management"
"Industrial Power"
International Filter Co.
International Combustion Engr. Corp.
Jenkins Bros.
Kelly Valve Co.
Keasbey & Mattison
Kieley & Mueller
King Refractories Co.
Kingsbury Machine Works
Ladd, Geo. T., Co.
Leather Lined Iron Pipe Co.
Leather Belting Exchange
Leddell Metals Co.
Liptak Fire Brick Arch Co.
London Steam Turbine Co.
Lopulco Systems
Lunkenheimer Co.
McLeod & Henry
Mack Engineering & Supply Co.
Manning, Maxwell & Moore
"Manufacturers Record"
Martin-Morse Corp.
Merritt, L. R, & Co.
Midwest Engine & Supply Co.
Mineral Oil Paint Co.
Murphy Iron Works
Nash Engineering Co.
N. A. S. E.
"National Engineer"
Olsson Corp.
Otis Elevator Co.
Philadelphia Gear Works
Pittsburgh Testing Laboratory
Pittsburgh Valve, Foundry & Construction Co.
"Power"
Power Specialty Co.
"Power Plant Engineering"
Pratt & Cady Co.
Pyramid Iron Products Corp.
Quigley Furnace Spec. Co.
Racine Machine Tool Co.
Rahmann, Geo., & Co.
Reading Steel Casting Co.
Reliance Gauge Column Co.
Republic Flow Meters Co.
Roto Co.
Ruggles-Klingeman Mfg. Co.
S. C. Regulator Mfg. Co.
Sanford-Riley Stoker Co.
Scovill Mfg. Co.
Schaeffer & Budenberg Mfg. Co.
Smith & Serrell
"Southern Engineer"
Spence, Paulsen Co.
Stewart-Sayer Co.
Superheater Co.
Sweets' Engineering Catalog
Tagliabue, C. J., Mfg. Co.
Templeton Mfg. Co.
Tidewater Oil Sales Corp.
Tracy Steam Purifier Co.
Uehling Instrument Co.
Underfeed Stoker Co. of America
Underfeed Stoker Co. of Canada
U. S. Cast Iron Pipe & Fdry. Co.
Vibration Specialty Co.
Vincent Gilsen Engr. Co.
Walworth Mfg. Co.
Watts Regulator Co.
Wheeler, C. H., Mfg. Co.
Wheeler Condenser & Engr. Co.
Yarnall-Waring Co.



STEAM POWER DEPARTMENT



Removal of Solid and Liquid Particles From Gases

By A. F. NESBIT*

SYNOPSIS

Combustible gases which are to be used as a source of heat or motor fuel, usually hold in suspension dusts or other particles which clog up mains, checker work, and passageways, or cause abrasive action on machined parts and interrupt the operation of motors.

For given weights of solid and liquid particles originating during chemical and manufacturing processes, many particles may present vastly different surface areas to the gases in which they are held in suspension. The carrying capacity of gases for these particles, for given velocities, may be very different, and the removal of one kind of particle from the gas stream presents a more difficult problem than the removal of another kind of particle.

Gases which are the product of combustion, partially completed, may contain solid and liquid particles of a redeemable value, or the discharge of these particles into the air may be injurious to health and vegetation, or may be declared a nuisance.

A brief description is given of experiments in removing dust from blast furnace gas, and pitchy and tarry particles from combustion gases.

Types of combined electrical and centrifugal, and of centrifugal gas cleaners are described.

Applications of these forms of cleaners are suggested for the removal of ash from hot and cold powdered coal combustion gases, also from producer gas. The recovery of hot cement dust from kiln gases and the utilization of heat in dust and in the gases in a special form of waste heat boiler or economizer are suggested. Application is made to the stage by stage recovery of several prominent soft coal by-products, and to the extraction of naphtha from natural gas.

THE cleaning of combustible gases may have for its object the preparation of the gas for service; first as a heating fuel, and second, as a motive power fuel; and the cleaning of hot gases which are non-combustible, or which may be the product of combustion already accomplished, may be carried out for the purpose of using the heat energy of the gases for the development of steam in waste heat boilers, with or without the simultaneous recovery of a by-product or the elimination of a dust nuisance.

Combustible gases, which may serve as a source of heat, are in many cases more desirable as a fuel, if their entrained dust and solid particles have been removed before they enter the combustion chamber of the apparatus used. Gases of this type have been cleaned very effectively by the washing process; but during the cleaning stages there has been a large loss of heat to the water employed, and a consequent lowering of the temperature of the gas. This low temperature cleaned gas, at the expense of its efficiency as a fuel, must now provide from its store of pent-up energy, as a chemical or mechanical mixture, the necessary source of heat that is required to raise its temperature to its original value before it entered the washer. A considerable saving of heat units may be effected by the use of a dry system of cleaning with a minimum change in temperature.

Combustible gases to be used as a motive power fuel, as in gas engines, must be effectively cleaned of entrained dust or other particles which in any way may interfere with the operation of the engine, or give rise to excessive wear of its parts and possible interruption of its operation. Washing processes have been very largely employed in the past, and serve the double purpose of cleaning the gas, while at the same time cooling it to any desired temperature, in anticipation of its admission into the explosion cylinders.

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*Consulting Engineer, Pittsburgh, Pa.

Hot gases which are noncombustible, and the heat which has not been utilized in any large way in the past, have been escaping into the atmosphere from all kinds of chemical, metallurgical, or roasting, and other processes, and little or no attempt, until within recent years, has been made to recover from its fumes waste products which have a redeemable value.

The fourth type of gas or air streams to be cleaned is that which contains in suspension solid and liquid particles which have no appreciable redeemable value, but the escape of which into the atmosphere may be considered a nuisance, and be the cause of financial loss or possible litigation.

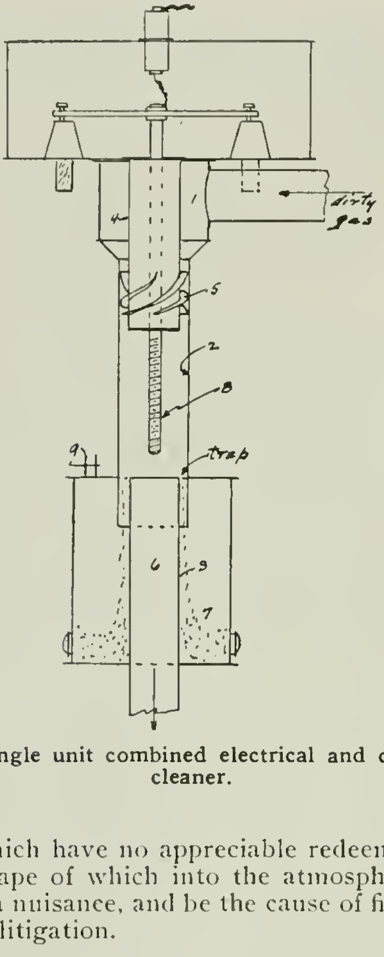

Fig. 1—Single unit combined electrical and centrifugal cleaner.

This article is intended chiefly to describe a type of apparatus which operates wholly upon mechanical principles or which may be combined to operate jointly with special structures constituting a combined mechanical and electrical gas cleaner.

The cleaning of gases coming under the individual requirements as here classified, necessitates a careful study of each case as a separate and distinct problem. This fact is appreciated when the physical and chemical properties of suspended particles is considered. The first of this series of articles referring to the mechanical type of cleaners, appeared in The Blast Furnace and Steel Plant in October, 1920.

The writer had the good fortune to have been associated with a special committee of engineers, under Mr. George E. Wisener, General Superintendent of the Mingo Works of the Carnegie Steel Company, at Mingo Junction, Ohio, in connection with research work on the application of the electrical precipitation process to the cleaning of blast furnace gas.

Tests of Combined Electrical and Mechanical Gas Cleaner.

During this study at Mingo Junction it developed that the most satisfactory method of automatically and continuously removing the dust from the grounded electrode pipe was by imparting a swirling motion to the gas stream and its entrained dust. The scouring action gave the best results, when the gas was admitted in a thin annular layer close to the stream boundary line. Fig. 1 makes clear the early form of apparatus used.

The gas velocities due to the varying gas pressure in the mains from which the dirty gas was taken, varied through wide ranges from 10 ft. to 48 ft. per second in the 8-in. diameter pipe.

The Apparatus.

With the apparatus shown in Fig. 1, the dust collecting chamber (7) would collect as much as 75 pounds of flue dust in an hour. The inner wall of the grounded electrode pipe (2) showed a clearly defined marking due to the scouring action of the swirling dust, and this marking extended to the lower end of this pipe. Electric current was supplied by a 5-kw., 50,000-volt, dc. generator of the Girvin type. This generator gave practically a sustained voltage and current wave so that all dust particles were charged to a definite voltage and at a definite polarity. The combined action of the centrifugal header supporting the stationary vanes (5), and the screw thread discharge electrode (8) was as follows:

The gas was free to expand radially inward at the lower edge of the six-in. dia. sleeve to which the stationary vanes (5) were fastened. The carrying capacity of gases is sometimes remarkable, and in this case such inwardly expanding gas carried with it a portion of the finer dust particles of ore and coke, and these particles by impingement upon the discharge electrodes, by the action of the electric wind from the screw threads and collision with previously charged particles, became charged with a definite polarity, and as such now constituted ionic dust streams which were driven into the swirling and scouring dust streams along the inner wall of pipe (2). At the upper edge of the clean gas discharge pipe (3), the annular dust stream along the inner wall of pipe (2) was sheared off from the central core or column of clean gas, and was collected within the chamber (7). The corona discharge from the rigid discharge electrode (8) was very uniform and intense, and the corona forming voltage and working voltage could be controlled very nicely.

Remarkable cleaning efficiency of the centrifugal header acting by itself and made up of the pipe sleeve (4) and the stationary vanes (5) of Fig. 1, and apart from an electrical equipment such as the discharge electrode (8) and its associated insulator and other structures, suggested a mechanical type of gas cleaner, with a wide range of possible applications. This type of mechanical gas cleaner with many modifications in structural form and method of isolating the dust from the clean gas, was suggested by one of my associates, Mr. Frank R. McGee, Chief Mechanical Engineer of the Carnegie Steel Works, at Mingo Junction, Ohio. Patents covering these ideas have been issued to Mr. McGee and other patentable material is under consideration or pending.

Mechanical Gas Cleaner.

The apparatus of Fig. 1 was stripped completely of the electrical system, and provision was made for many adjustments of the position of the centrifugal head relative to the annular dust trap, the nozzle opening between the vanes, etc., and a series of tests made with this altered structure.

Any dust which passed out of this cleaner discharge pipe was collected by means of an electrical precipitator, except such dust as settled or was trapped in the short pipe connections between this structure and the precipitator. The dust collected in the chamber (7) of this apparatus (see Fig. 1) was weighed, and the total dust collected in the precipitator and connecting pipes was weighed. During these tests the electrical precipitator was operated so as to collect all dust that passed through the centrifugal cleaner and the connecting pipes. The ratio of the weight of flue dust caught by the annular trap, to the total weight of dust passing through the centrifugal cleaner, gave values as high as 97½ per cent, as the efficiency of this type of cleaner in single units. These results could be repeated at will.

A rather exhaustive series of tests were conducted with apparatus similar to that shown in Fig. 1 and with pipes (2) as large as 16 inches inside diameter. The results were in everyway comparable with those using the 8-in. diameter pipe structure of Fig. 1. During the coldest weather of the winter of 1917-1918, the 16-gauge galvanized iron pipes which were over 100 feet long and supplying dirty gas to the cleaner were exposed to atmospheric temperatures, and until the system was well warmed up, for each day's run, the water vapor condensed in the apparatus was collected along with the dust and formed a wet mud in the collecting chamber.

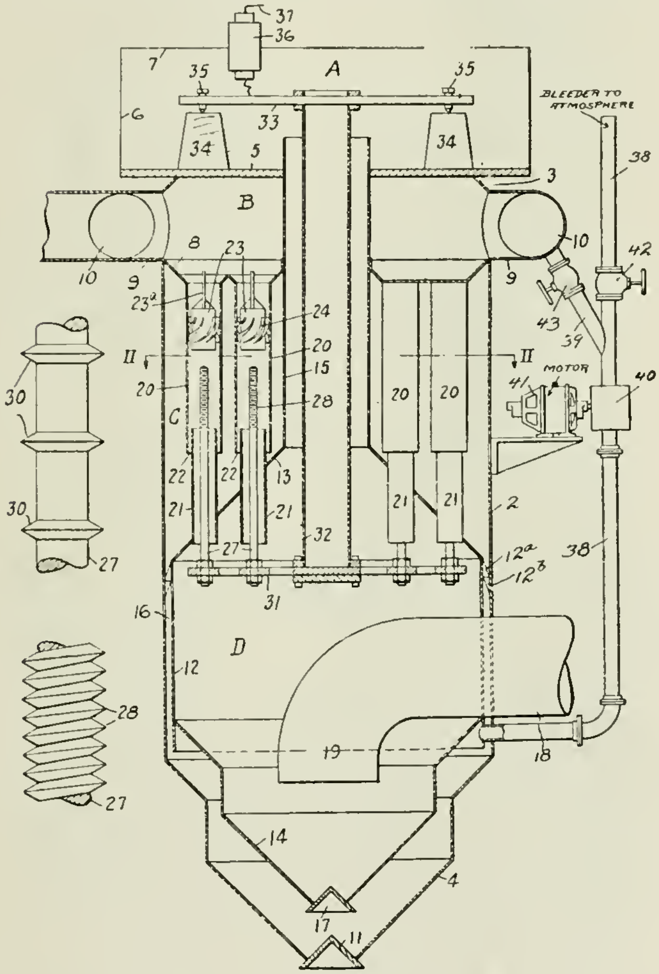

Fig. 2—Multiple unit combined electrical and centrifugal cleaner.

Even though the unsettled conditions, which have effected business and the industries since the world war, have given rise to regretable delays and interruptions toward reaching a final form of this centrifugal type of structure for cleaning blast furnace gas, the work is, however, going on as rapidly as possible. Apart from work which has been done, up to date, at Mingo Junction, Ohio, the writer has been in close touch with, or actually conducted many additional tests with hot and cold gases which have contained solid and liquid particles, which have differed widely as to their physical and chemical characteristics.

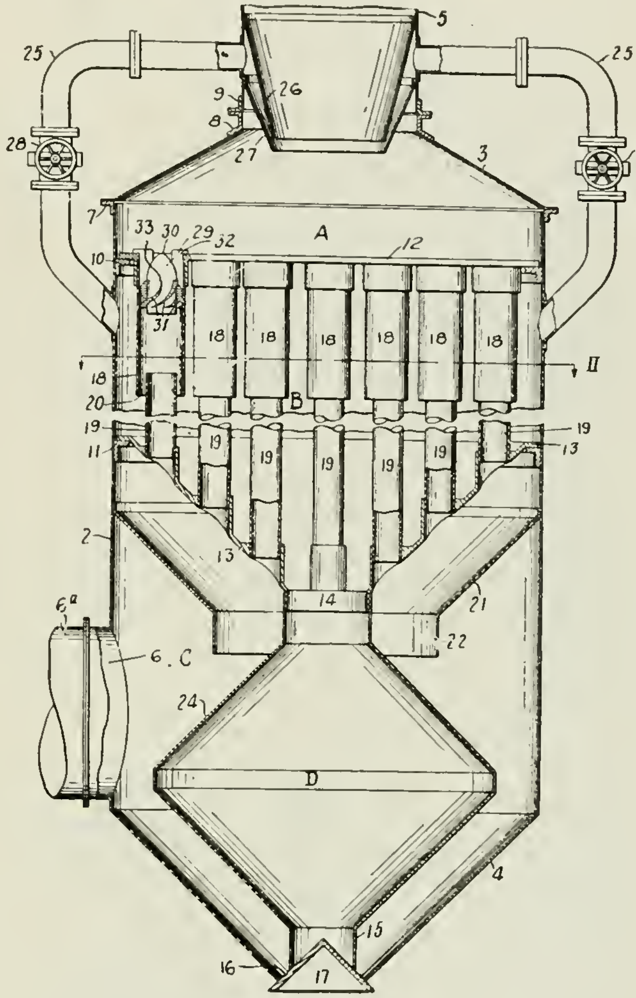

Fig. 3—Multiple unit centrifugal cleaner.

Research Work on Pitchy and Tarry Products.

Tests which the writer has made with unit cleaners of this type have taken pitch and tarry gases cooled to temperatures as low as from 36 to 13 deg. C., and by slowly passing steam through a concentric jacket surrounding the pipe (2) of Fig. 1, the tar and pitchy products which had been thrown out against the inner wall of this pipe (2) was kept on the move, along with the water particles also present in the dirty gas stream, and both were thrown through the trap into the collecting chamber. This steam jacketing effect upon the inner wall was made only large enough to keep the layer of tarry and water particles in a thin layer and on the move and so as not to produce an appreciable re-evaporation of these particles. For the automatic removal of pitchy, tarry and other distillate products, which would freeze to the pipe and the centrifugal header at these low temperatures, it is necessary to design the header so that it may be fed with stream or circulating water and properly drained.

Description of Multiple Unit Combined Electrical and Centrifugal Gas Cleaners.

Fig. 2 represents one proposed form of combined electrical and mechanical gas cleaner, made up of a multiple grouping of individual units. The gas enters the distributing chamber B and passes down through the individual cleaner units, the operation of each one of which is identical with that outlined for Fig. 1.

The electrical system of Fig. 2 is very rigid and compact, and equipped with an electrode system of short co-operating length, supplies an intense and almost solid static electric field through which the gas and its dust must pass. This short electrode system is particularly valuable, so that the swirling action may not be materially weakened due to a long travel, until the dust and other particles are safely sheared off from the central clean gas column.

In this structure of Fig. 2, the individual dust traps are properly connected and one communicating dust chamber C, so designed that the discharge of the collected dust may be made automatic. All of the clean gas outlet pipes, from these individual cleaner units, discharge into one clean gas chamber D, from which one discharge outlet is shown. In both figures (1) and (2), the pressure relief valves (9) and (43) respectively, make provision for keeping the gas pressure in the dust collecting chamber of such a value as to avoid a back pressure against which the dust must be discharged through the traps, or to avoid a dead air space. This pressure relief system may be preferably such as to recirculate such a portion of the gas as may be found necessary for the results required. This provision is made in Figs. 2 and 3.

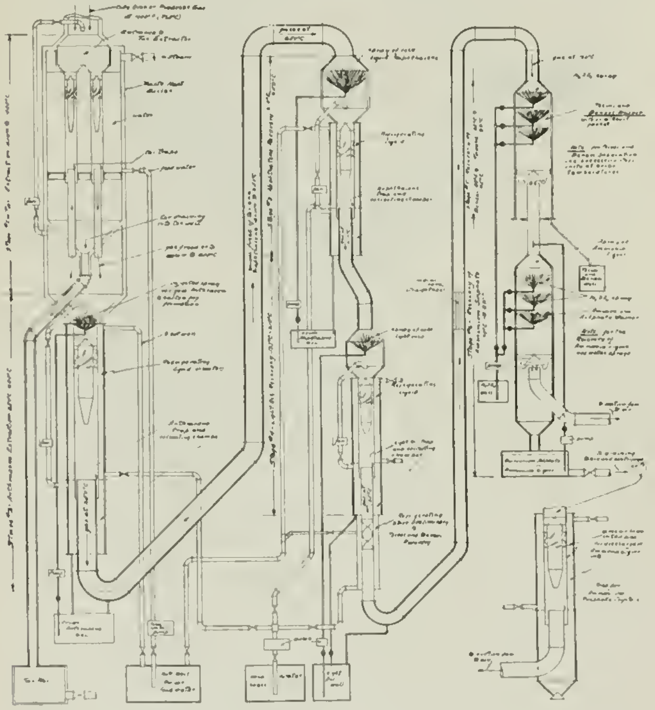

Fig. 4—By-product recovery.

Description of Multiple Unit Centrifugal Gas Cleaner.

Unit cleaners, of the type shown in Fig. (1), with properly associated concentric jackets for steam, or refrigerating brines, but stripped of the electrical system, do not remove as completely the dusts, tar and other fogs constituting the recoverable contents of the gas, as may be done by the use of the combined electrical and mechanical cleaners. The strictly mechanical unit cleaners are free, however, from the attendant disadvantages always present when using electrical systems, and they yield such a high percentage of recovery as to suggest a successive stage refrigerating type of apparatus, as will be shown later in this article.

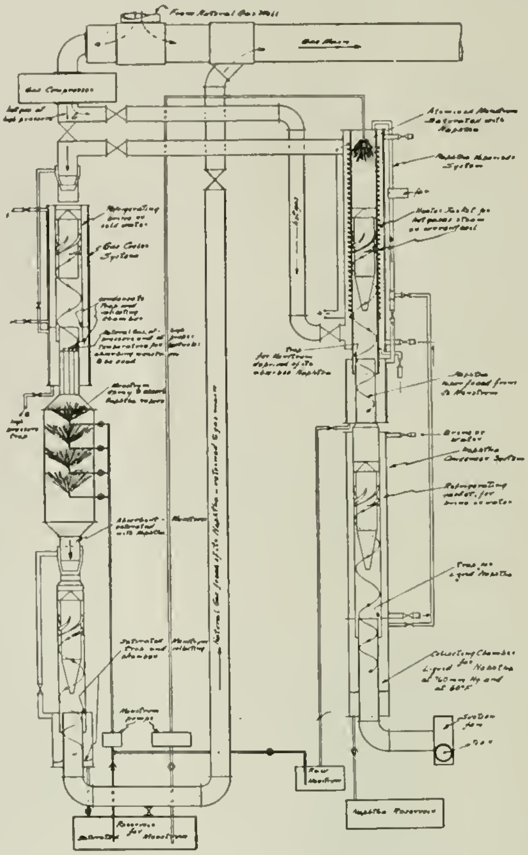

Fig. 5—Evtraction of naphtha from natural gas.

Fig. (3) shows a mechanical cleaner, in substance, identical with that of Fig. (2), when the electrical system of the latter has been removed and the structure correspondingly simplified. In Fig. (3), A is the admission chamber for the dirty gas. The multiple grouping of the individual centrifugal cleaning units discharge the dust and clean gas into their appropriate collecting chambers, B and C just as was the case with the combined cleaner of Fig. 2.

In the suggested forms and groupings of cleaner units for the special problems which follow, each particular problem will have its own peculiar difficulties to be met and overcome. Modifications and refinements will necessarily have to be made in order to do the work required and these probable difficulties which may suggest themselves in advance of actual tests may not be insurmountable.

In addition to the applications suggested in the following paragraphs, the centrifugal structure is especially well adapted as a steam separator, an air dryer in compressor system, a collector of saw dust and dusts from grinding and other processes.

Suggested Cleaners for Removing Ash from Hot Powdered Coal Combustion Gases.

It is entirely possible to design and build a structure which will meet the extreme demands of removing the ash dust from hot powdered coal combustion gases previous to the admission of these hot gases into annealing and pottery ovens.

The feasibility of this structure was carefully considered by the engineers of one of the tin plate companies and one of the manufacturers of high grade refractory material, and it was thought to have possibilities worth determining not only for their own individual needs, but for use in chemical, metallurgical, glass, cement and other industries where the contamination due to the ash is prohibitive.

Collection of Ash from Stack Gases at Power and Other Plants

A multiple unit structure along the lines suggested by Fig. 3 should serve admirably to collect the ash from powdered coal combustion gases, the collection being made after the gases have passed through the furnace or boiler and before they enter the stack or chimney.

The Recovery of Cement Dust from Hot Cement Kiln Gases, and the Simultaneous Extraction of the Heat In the Gases and Dust for the Development of Steam In Special Waste Heat Boilers.

This application offers a very promising field for this mechanical type of gas cleaner. A further development of this idea suggests a single unit waste heat test boiler for this purpose, into which the hot kiln gases enter at 1,200 deg. F. to 1,400 deg. F. and the centrifugal header throws them into a thin helical swirling stream against the inner wall of a water jacketed pipe.

One of the chief difficulties encountered in passing hot cement kiln gases through the present types of fire tube and water tube boilers, is that the straight flow of the gases through the fire tubes, or the torturous passage through a nest of water tubes, is very favorable to the freezing of the hot dust to the comparatively cold surfaces of these tubes.

Recovery of Ash and Earthy Matter From Producer Gas

Judging from the ease with which the coke dust may be collected simultaneously with the ore dust from blast furnace gas, these two dusts being in the same proportion that exists in the dust collected in the dust legs, and the collection of many other finely powdered dusts by this apparatus, there is every reason to believe that simple groupings of individual centrifugal cleaning units should serve very satisfactorily for removing by a dry method even at high temperatures, the ash, earthy and other undesirable solid particles from producer gas preparatory to its use as a fuel in ovens, metallurgical processes and in the manufacture of glass.

The Recovery of Soft Coal By-Products.

Another application of the centrifugal jacketed units might well be designed for a series stage by stage successive recovery of several of the soft coal by-products as suggested by Fig. 4.

Extraction of Naphtha from Natural Gas.

Fig. 5 suggests the application of this type of single centrifugal jacketed unit to the extraction of naphtha from natural gas. It is believed that this apparatus or modifications of it may be well suited for portable or other systems which may be used in weak pressure gas fields, where the gas supply is too small to warrant the installing of piping and pumping systems.

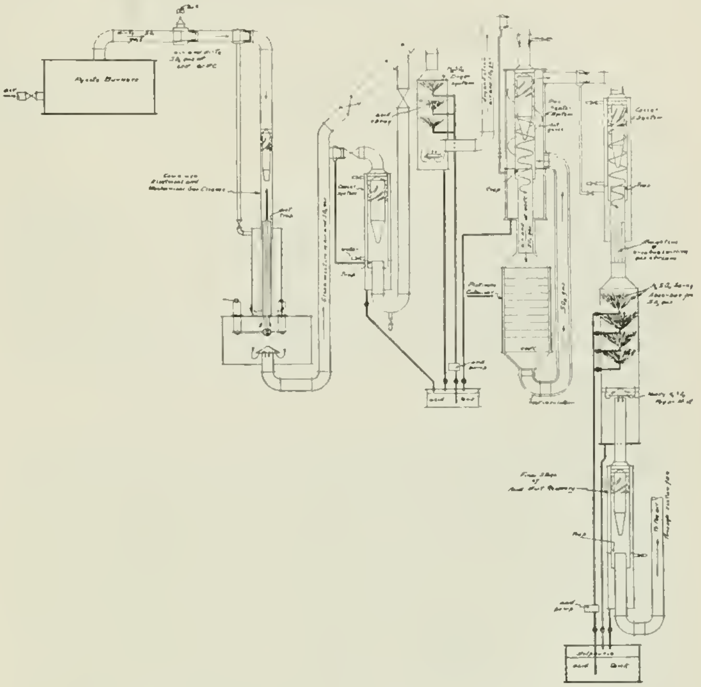

Fig. 6—Contact process of making H_2SO_4.

The Manufacture of Sulphuric Acid.

A proposed combination of centrifugal units of this type is shown in Fig. 6, and is equally well adapted to the manufacture of sulphuric acid by the contact process, as by the chamber process. Other fields of application for this type of mechanical gas cleaning apparatus, than those here mentioned will suggest themselves to the engineer, chemist and others.

Disadvantages and Advantages of the Types of Cleaners Here Described.

The combined alectrical and mechanical apparatus or the electrical precipitation apparatus by itself, have their chief disadvantages appear as leakage, sparkover and possible danger from high voltages. These elements, it is believed, are guarded against as far as it is possible to do so, in the apparatus suggested in this article. They are of simple and rugged construction; the insulators are in clean gas regions; the electrode systems are practically free from vibration and easily kept in alignment; the combined action of the centrifugal head and the electric field make the most efficient type of gas cleaner known.

Some of the advantages of the strictly mechanical or centrifugal unit systems of cleaners are:

(a) They are simple and rugged in construction.

(b) Low first cost and low cost of operation.

(c) Continuous and automatic in operation.

(d) Require little or no attention.

(e) Makes possible the cleaning of gases at wide ranges of gas velocity, and depending upon the properties of the particles to be collected.

An Investigation and Discussion of Slag Formation on Boiler Tubes

Conclusions Arrived at After Extensive Tests—Boiler Operation and Methods of Preventing Slag Formation on Boiler Tubes.

By HARRY H. BATES*

THE trend of recent boiler and stoker development is toward the extremely large units, which are operated at capacities far beyond those that were considered normal a few years ago. The fact is that it is a daily occurrence to hear of boiler stations operating at 300 per cent of rating or more, and it is by no means unusual that 400 per cent of the rated capacity and more are reached.

These large boiler and stoker units with their large grate areas and high gas velocities caused by high capacities, have brought about problems that have reached considerable magnitude in the combustion field of engineering. Most of these problems have existed ever since coal has been used for fuel purposes for steam generation, but until quite recently the small, easily accessible units used did not serve to indicate the extent of the trouble that would be involved. With the introduction of the large units it has become necessary to study these problems, and experiment in furnace construction in order to eliminate, as far as possible, the difficulties encountered.

One of the most serious, as well as most baffling, of these problems is the formation of slag on boiler tubes. That this is a problem that can become serious is shown on Fig. 1, and it is to be stated that the slag shown was deposited in less than one week of operation, in spite of all the care and work done in attempting to remove it.

To determine the exact means by which the material is deposited and the chemical reactions that actually take place is a very difficult task, but after six months' investigation of the subject, certain deductions were arrived at. During the entire investigation it was constantly borne in mind that to effectively overcome the slag problem it would first be necessary to establish the cause of its formation, how it is carried up to the tubes, and the form in which it is deposited.

The Similarity of Causes of Clinker and Slag.

In discussing the problem of slag formation on boiler tubes, it is well that a brief discussion be given on the formation of clinkers in the furnace itself. The slag found on the boiler tubes and furnace walls is of the same material as the clinker that is discharged from the furnace, and the causes of one are to a large extent the causes of the other.

The principal constituents of ash are silicon dioxide (SiO_2)(aluminum oxide (Al_2O_3), ferrous oxide (FeO), ferric oxide (Fe_2O_3) and lime (CaO). There are other materials present, but they are in such small quantities that their presence and effect are practically negligible and will not be discussed in this paper. Table 1 shows the atomic weights of the principal constituents of ash as well as their fusing temperatures.

TABLE 1—PRINCIPAL CONSTITUENTS OF ASH AND THEIR FUSING TEMPERATURES

Oxide	*Formula*	*Atomic Wts.*	*Deg. F.*
Silicon dioxide..	SiO_2	60.30	3227
Aluminum oxide	Al_2O_3	102.20	3416
Ferrous oxide. .	FeO	71.84	2586
Ferric oxide....	Fe_2O_3	159.68	2840
Lime	CaO	56.07	3452

Table 1 is of particular interest because, with the one exception of ferrous oxide, there is not one of the principal oxides of which the ash is composed that will fuse at ordinary furnace temperatures alone. It is when these oxides are heated in intimate contact with each other that the real clinker forming properties present themselves. The basic oxides act as fluxes on the silica present with a lowering of the fusing temperatures of the combined material. The fusing temperature is dependent upon the oxides that are brought in contact with the silica and the proportion of each. These basic oxides, together with the silica, form monosilicates of the gen-

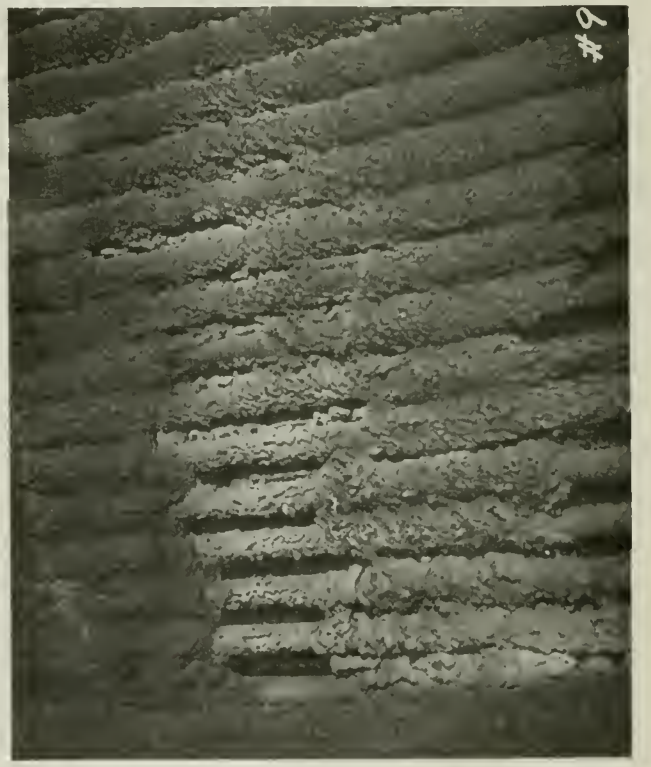

Fig. 1—Accumulation of slag on horizontal water tubes so heavy boiler became inoperative.

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*Assistant Engineer, Stoker Department Westinghouse Electric Mfg. Co., Philadelphia, Pa.

eral form of CaO (SiO_2), etc. These monosilicates have a very much lower fusing temperature than the oxides of which they are composed. As an example of this fluxing action, pure silica fuses at 3227 deg. F., pure ferrous oxide fuses at 2586 deg. F., but ferrous silicate fuses at 2318 deg. F. If lime is added to this silicate in various proportions the fusing temperature may be anything down to 2066 deg. F. From the above it may be said that ferrous silicate alone, or in combination with lime up to about 40 per cent of the total ash, will give a fusing temperature well below ordinary furnace temperatures.

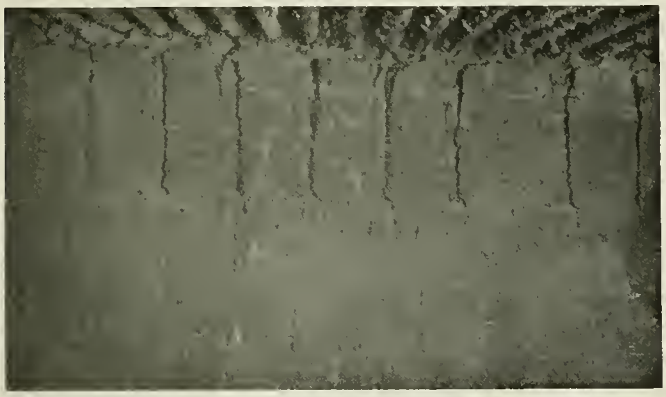


Fig. 2—Action of slag on boiler walls and tubes. Note the erosion of walls where C. I. hangers supported soot blower element.

Tests made by the United States Geological Survey indicate that the tendency of ash to clinker is increased as the per cent of iron increases, but this may not be true invariably.

Iron combines with the silica in the form of ferrous or ferric oxides, but not in the form of sulphides; however, it is only a matter of supplying heat and oxygen to convert the iron into its ferric state.

The per cent of sulphur found in an ultimate analysis of coal is frequently blamed for the excessive formation of clinkers, but sulphur is not a slag forming material in itself. It is usually found in the fuel as sulphates or pyrites, which is ferric sulphide. The sulphates are not troublesome to a great degree, but the larger portion is in the form of pyrites and it is the iron in this combination that really is the disturbing factor.

The United States Bureau of Mines has made an extensive research of the sulphur forms in coals. Table 2 gives the relative proportions of the several forms, as obtained from their Technical Paper No. 254, by A. R. Powell.

It will be noted that the pyritic sulphur comprises from 40 per cent to 60 per cent of the total sulphur, except in the Pocahontas and Elkhorn coals, and these coals are generally considered very high grade steaming coals and give a minimum of clinker trouble. If sulphur accompanies the mixture it retains its form as ferrous sulphide and this material, in conjunction with silicious matter, makes an even more easily fusible mass than those already given.

Relation of Clinker Forming Properties of Ash to Formation of Slag on Boiler Tubes.

The above discussion of clinker formations also applies almost in its entirety to slag formations on boiler tubes and walls. The condition is suggested that the iron must be kept in its ferric state, which is practically infusible. This can only be done by completely oxidizing the sulphur and iron before the tubes are reached. No free oxygen passes through a well broken up fire. (United States Bureau of Mines, Technical Paper 139, and Bulletin 135.) Unless excess air is added over the fire an incomplete combustion of carbonaceous matter and other oxidizable substances results. For this reason it can be considered with reasonable surety that complete oxidation of all slag forming constituents cannot be accomplished within the limits of the fuel bed proper. The inherent characteristic of the underfeed type of stoker to burn fuel more rapidly ove the tuyere rows than over the retorts aids materially in suppliing the required distribution of oxygen for the complete oxidation of all oxidizable matter, but, even with this type of stoker, slag formations on the tubes and furnace walls are a serious problem with some coals.

Sulphur Form	*Upper Freeport, Pa.*	*Pittsburgh, Pa.*	*Pocahontas, W. Va.*	*Elkhorn, Ky.*	*Coal Creek, Tenn.*	*Cherokee, Kan.*
Pyritic sulphur ..	.47	.79	.08	.13	1.75	1.99
Sulphate sulphur.	.07	.23	.01	.04	.71	.32
Organic sulphur..	.62	.66	.46	.51	1.78	.71
Total sulphur....	1.16	1.68	.55	.68	4.24	3 02
Per cent of Pyrites in total sulphur..	40.5	47.0	14.5	19.1	41.3	66 0

It can here be said that all types of stokers, underfeed, overfeed and chain grates, have difficulty with slag formations. Even a low velocity gas from a quiet fire on a natural draft stoker will carry quantities of this slag with it and deposit it on the tubes and walls.

How Slag Is Conveyed to and Deposited on the Tubes and Walls.

The above facts, especially those concerning the slag being carried to the tubes at all boiler ratings and gas velocities, suggest that the slag particles are carried up

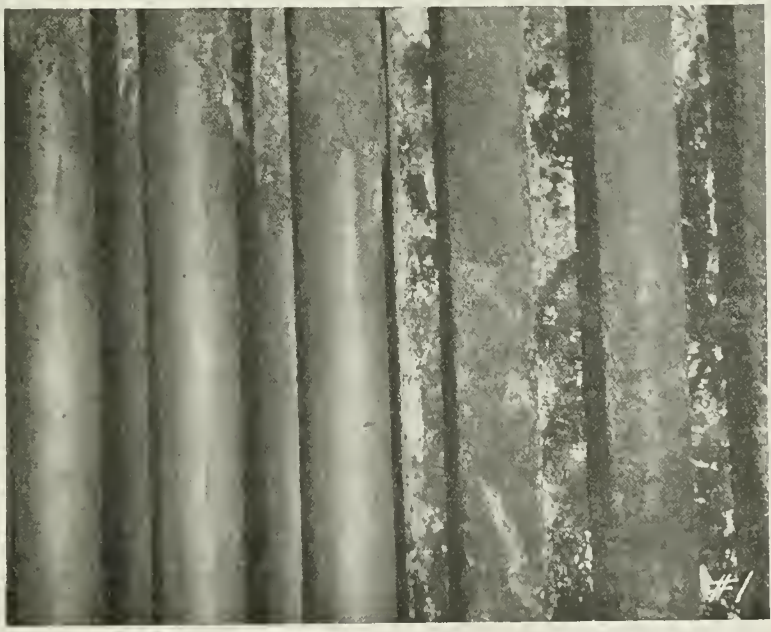


Fig. 3—Slag formation on vertical water tubes, showing left side tubes with slag scraped clear and right side tubes with slag knocked down.

with the draft in such minute form that they can be carried with the low velocity gas as well as the gas that rises rapidly. An examination of the slag under the microscope revealed small spherical globules which substantiated the belief that the particularly troublesome particles were the small ones.

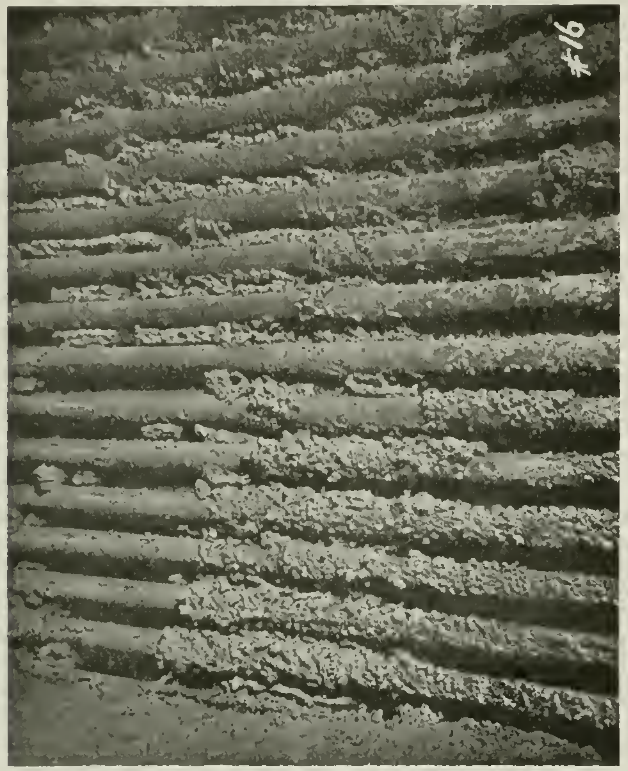


Fig. 4—Slag formation which badly interferes with passage of gases.

When these little particles come in contact with the free oxygen in the furnace gas for a sufficient time to completely oxidize them they will be transformed into their completely oxidized state and become solid. If they solidify before touching the tubes or walls they are carried through the boiler as solid ash. On the other hand, it has already been pointed out that no free oxygen is obtained through the fuel bed. In this event the particles remain in a molten condition, on account of their low fusing temperature in their -ous state, and are deposited on the tubes and walls where they may either be completely oxidized and solidified or be covered by successive coatings or layers of the same plastic material. That the latter is true to a large extent is shown by layers of a very dark vitreous material covered by a reddish brown layer or protective coating. This reddish coating is largely ferric material and it prevents further oxidation of the dark ferrous material within by excluding the oxygen from it. A considerable portion of the material on the outer surface, especially on the tubes, is of a friable and non-fusible character, and it is of a completely oxidized nature.

Devices for Admitting Excess Air to the Furnace Gases and Their Effect.

A number of manufacturers of stokers and stoker auxiliary equipment have produced equipment for supplying excess air over the fire in order to completely burn combustible gases. They have undoubtedly accomplished some beneficial results, but, even now, there is yet considerable research and experimental work to be done on the extra large, super-power station type of boilers. The extreme size of these furnaces make correct distribution of air to the furnace an extremely difficult problem to solve. The nearest approach to a suitable device so far developed is an installation with perforated cast iron air distributing boxes above the throat of the stoker.

Another type of equipment frequently used for this same purpose is the ventilated wall of perforated fire brick. This method is satisfactory for the ordinary size of furnace, but for the larger units a very strong jet action is required to force the air to penetrate the rapidly rising volume of gas to a distance sufficient to oxidize the particles in the center of the gas passage. These devices serve well for protecting the boiler walls, but can not be considered as suitable for slag prevention in large furnaces.

Even if some efficient means is developed for mixing the gas and excess air together, it is very questionable whether the slag difficulty will be entirely overcome. It is to be remembered that in addition the problem of supplying and mixing the oxygen and combustible gases, time is required for the various chemical reactions to take place.

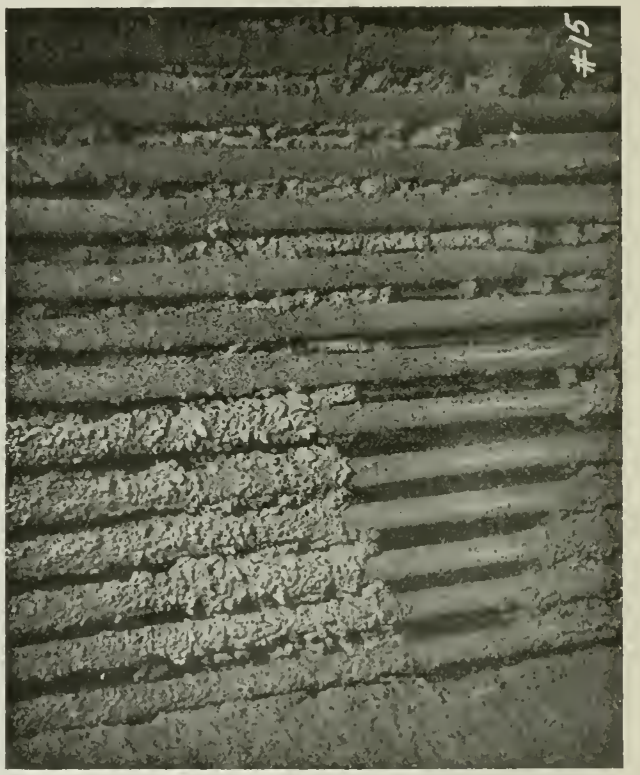


Fig. 5—Another typical illustration of serious slag formation on horizontal water tubes.

There is but little chance for thoroughly mixing all gases in the combustion chamber, as the rapid rate with which the gases ascend prevent a thorough mixing and a stratification of the gases results. An illustration of this is shown on Chart I. These figures are values of CO_2 from gas samples taken under every second tube and at 2-foot intervals along the tubes vertically baffled.

These readings showed a carbon dioxide content of from 10.0 per cent along the walls to 17.5 per cent in the center. From these figures it can be appreciated that the chances for the ferrous material to change into the ferric state are very few. It was very evident that there was an insufficient penetrative effect from the ventilated walls

ANALYSES OF SAMPLES TAKEN FROM FIRST PASS BAFFLE OPENING IMMEDIATELY UNDER THE FIRST ROW OF TUBES

Tube No.	41	37	31	27	23	19	15	11	7	3
CO_2	10.6	11.0	11.4	15.0	15.3	16.2	13.0	12.4	13.4	10.5
	10.1	12.0	14.0	16.0	17.5	13.4	13.0	12.8	12.8	13.0
	10.0	12.8	15.5	16.5	17.8	13.0	14.5	13.7	10.2	13.7
	11.9	10.5	14.9	15.7	17.9	14.3	14.0	14.3	13.4	10.6

to take care of the wide furnace, and also it is noted that there was considerable excess air along the walls.

Composition of the Slag on the Tubes and Furnace Walls.

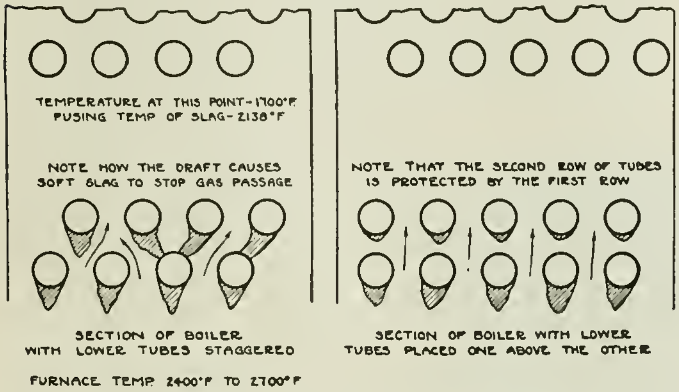
Numerous samples of coal, ash, and slag were analyzed, the last of which are particularly interesting because they corroborate the above conclusions.

Table No. 3 gives a typical analysis of the slag taken from both the boiler tubes and the furnace walls.

TABLE 3—TYPICAL ANALYSES OF SLAG

Sample of Slag Taken from Furnace Walls	
Ferrous iron	8.26%
Ferrous iron calculated to ferric iron	9.18
Ferric iron, found as such	6.71
Total iron	15.89
Ratio of ferrous iron to total iron	57.7
Sample of Slag Taken from Boiler Tubes	
Ferrous iron	3.23%
Ferrous iron, calculated to ferric iron	3.58
Ferric iron, found as such	8.21
Total iron	8.71
Ratio of ferrous iron to total iron	29.1

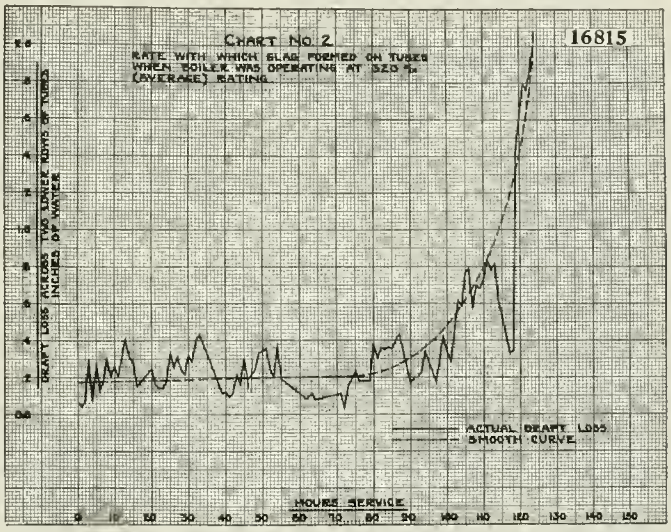
Chart I


TEMPERATURE AT THIS POINT-1700°F
FUSING TEMP OF SLAG-2138°F
NOTE HOW THE DRAFT CAUSES SOFT SLAG TO STOP GAS PASSAGE
SECTION OF BOILER WITH LOWER TUBES STAGGERED
FURNACE TEMP 2400°F TO 2700°F
NOTE THAT THE SECOND ROW OF TUBES IS PROTECTED BY THE FIRST ROW
SECTION OF BOILER WITH LOWER TUBES PLACED ONE ABOVE THE OTHER

It is interesting to note that the slag on the furnace walls ran much higher in ferrous iron, by per cent, than did the slag on the tubes. In consequence of this the slag on the walls was much freer from the coarse friable infusible material than was the material on the tubes. The hard vitreous appearance of the slag on the walls gave evidence of having been there in a molten and flowing condition until such time as the furnace was cooled below the fusing temperature of the mass. The smooth appearance of the wall shown on Fig. 2 as compared with the rough material on the tubes, shown on Fig. 2, further verifies this point.

Numerous theories were advanced during this investigation as to the causes of slag formation on the tubes. Chief among these was the condensation of tarry vapors on the tubes to which the flying particles could adhere and solidify. It is true that the coal contained a high percentage of volatile matter and was rich in tars, but that this had a material effect in the formation of the slag is highly improbable. If tarry vapors existed in the ascending gases and actually condensed on the tubes any coating on the tubes would be extremely thin. Tars are fairly good heat insulators and only a very thin coating of tar would form before it would begin to burn away when subjected to the furnace temperature, which at times was 2800 deg. F. to 3000 deg. F. Even if the lack of temperature permitted the film of tar to form on the clean external surface of the tubes, the insulating effect of a very thin layer of slag would prevent further condensation of tar. That this did occur was borne out by the fact that only about 1/16 in. to ⅛ in. of the slag on the tubes remained there in a completely frozen state. The melting point of the slag was 2138 deg. F., which is much above the vaporizing temperatures of any tars in the fuel and, consequently, a condensation of these tars would be impossible.

Chart II—Showing rate of slag formation which is shown at end of test run in Fig. 1.



As commonly found in furnaces of all kinds, a considerable amount of visible solid particles were carried up with the rising gases. On the clean tubes these did not appear to have any effect, as they simply struck the tubes and rebounded, sometimes falling back in the furnace, or were carried through the boiler with the gases. Chart II is interesting in that it shows how rapidly the draft loss increased across the two lower rows of tubes, after an adhesive coating of molten slag had formed on the under sides of the tubes. After this coating had formed a great portion of the solid particles struck and adhered to the plastic material and the rapidity with which the slag formed was greatly increased, both by this and the rapidly growing area presented for contact.

On the large number of tests made it was indicated that the slag deposit on the tubes was nearly proportional to the total amount of gas, and was not greatly affected by the rating. The amount of slag was affected by temperatures in the furnace, however, for the hotter fires kept the slag in a more viscous state which greatly increased the tendency for cinders and particles of ash to adhere.

Experiments Made to Prevent Slag Accumulation.

As previously stated, the slag problem is a chemical one and the desirable remedy would be a chemical remedy, providing the cost of maintaining chemical action is not excessive. Such action may be set up in three different ways:

First—By feeding some material in with the coal that will act as an oxidizing agent.

Second—By feeding some vapor in with the air supply, which will dissociate and permit its oxygen to combine with the ferrous material present.

Third—By intimately mixing air, at high temperature, with the rising particles, so as to completely oxidize them before reaching the tubes.

By analysis of these three courses for experiments the first one was eliminated without trial. It was not considered feasible to feed any solid oxidizing substance in with the coal. The first cost would certainly be prohibitive, besides a greater amount of ash would have to be handled.

The second procedure was tried out by the injection of steam into the air supply. No decrease was noticed in the formation of slag on the tubes.

It is to be remembered that at no place in the fuel bed, except on the dumps, could the ash have been over 50 per cent of the total fuel bed. Further, the ferrous material was not over 10 per cent of the ash. It is, therefore, apparent that the ferrous material, representing a maximum of 5 per cent of the total fuel bed, had but little chance of coming in contact with the liberated oxygen and solidifying in its ferric state.

In reality this was expected, as it was deemed impracticable to put enough water through the fuel bed to insure complete oxidation of the ferrous material with all the other combustible matter present.

More recent experiments have shown that the introduction of water vapor into ash and refuse undoubtedly prevents a spongy mass of clinker from adhering together. This, however, is a vastly different proposition from the former, as it is necessary only to oxidize the surface to prevent adhesion where about 80 per cent of the material present is incombustible.

The third method suggested, namely by intimately mixing air with the gases, is now being tried. The original boilers were set about 13 feet from the grates. It was thought that, by increasing the distance between the grates and boiler tubes, the gases would have more opportunity to mix thoroughly. Also, since the total time of travel of the furnace gas is dependent upon the velocity and distance of gas travel, more time would be allowed for complete oxidation of the small particles. Consequently, a boiler was set up six feet higher than those originally installed.

Assuming that the rapidity with which the gas rises from the fuel bed is uniform, it is calculated that its velocity was about 18 feet per second. This is the lowest possible velocity that can be expected. The direction of gas travel is from the grate direct to the baffle opening, which was proportioned as 46 per cent of the grate surface. Necessarily the velocity was twice as high under the baffle as it was leaving the fuel bed.

On this basis, the time it took for particles to reach the tubes with the original installation would be 13 ft. ÷ 18 ft. = .72 sec. This is very little time for oxidation to take place, unless it is of an explosive character. Further, by raising the boiler to 19 ft. this same time would be 19 ft. ÷ 18 ft. = 1.05 sec., which is still of very short duration.

This arrangement has not shown any great improvement in slag prevention and has the disadvantage of exposing more brickwork to high temperatures and to draft with resulting greater infiltration of air through the setting.

Furnace construction undoubtedly has much to do with the external encrustation of the tubes with slag. The ratio of the exposed tube surface to the grate area was 1 to 1. This is very low and the lower the ratio, under set conditions of fuel and fuel bed, the higher will be the furnace temperature. It is apparent that the higher the furnace temperature the greater will be the tendency for the ash to fuse and stick.

It has become common practice now to have the ratio of exposed tube surface to grate surface as high as 1.87 to 1, and is seldom less than 1.2 to 1. By increasing this ratio the amount of heat radiated up and absorbed is very materially increased with a consequent reduction in furnace temperature.

This last item, namely furnace construction, is a step in the right direction. Unfortunately, the construction of the investigated installation did not permit changing the ratio (1 to 1), and, for comparative purposes, it was necessary to refer to a neighboring station with a similar type of stoker and boiler, and which used a similar coal. This second plant has had practically no trouble with slag on tubes and uses only the soot blowers while the boilers are in operation.

An interesting difference in the two stations was that the first two rows of tubes in the former were staggered, and slag impinged on and stuck to both rows. The second row caused more trouble than the first row, as the slag took the form of icicles or stalactites and when they became long enough and the velocity of the gas became high enough, the "icicles" bent sideward until they touched the lower tubes. This effectively sealed the gas passage of that part of the boiler. (See Chart III.)

The second installation had the first two rows set one above the other. The material which struck the bottom row of tubes adhered, but the rapidity of the formation was far less. On account of this arrangement, the gases were sufficiently cooled by passing between these tubes to prevent the slag from sticking and there was no further tendency for the slag to adhere to the boiler surfaces.

When it is considered that the ash is very finely divided in the coal, and that some of it is certain to be carried up with the gas, it appears that the most fruitful field for development of means for slag prevention is in furnace and boiler design. This belief has already been justified. At the same time there is still need for further development of apparatus for mechanically removing soot and slag from boiler tubes.

From the foregoing it is seen that the chemical composition and fusing temperatures of the ash were known, and a careful and complete record was obtained of all happenings in the furnace and around the boiler. With the aid of this information and the assistance of the United States Bureau of Mines, evidence was obtained that has led to the above general conclusions.

Considerable value was received from this investigation because much was learned of the effect of furnace, boiler and stoker construction on the slag problem.

It is extremely fortunate that only a comparatively few coals give slag trouble to a serious degree. A great many coals have fusing temperatures so high that they give no trouble with ordinary furnace temperatures. Another class of coals have low fusing temperatures, but do not seem to have the tendency to be lifted from the fuel bed. But when a coal gives serious slag trouble, with the present knowledge of the art of burning coal, means must be provided for its mechanical removal. This, however, is not as serious a matter as it appears, for soot blowing in boiler plants is now recognized as a necessity, and apparatus for soot removal is now installed as a regular boiler equipment.

Boiler Feed Water—As it Ought to Be—Zero Soft

Continuous Uninterrupted Power Demand by Steel Mills—Boiler Scale Costly and Unnecessary—Commercial Synthetic Zeolites.

By ERNEST ROWE*

SO heavy and continuous is the duty demanded of the power plant in the blast furnace and steel mill, so high is the ratio of the power factor to total value added by the processes of the industry, that its operation, both from the mechanical and cost standpoints, is highly sensitive to conditions, good or bad, which affect the production of power or the cost of its production. In a silk mill or an oil refinery the loss involved from the ordinary troubles with the power plant appear in the value of the finished product as an infinitesimal fraction. But in the steel mill the influence of unrestricted power supply is immediately felt throughout the production sequence, with an effect so cumulative that costs and selling prices are seriously affected.

Boiler scale is one of the most serious troubles encountered by the average blast furnace or steel plant, and the reason is not far to seek. Not enough intelligent interest is shown in the matter.

The water supply, from which most furnace and steel plants in this country derive their boiler-feed, is anything but ideal, often high in free acid, usually bicarbonate, and always heavy with incrusting solids. From the very nature of the operation, most boiler houses are small and scattered, not particularly well designed, and poorly operated. Many of the steel plant mill engines, especially the older ones, operate non-condensing, a large percentage of those condensing use jet condensors and no attempt whatever is made to recover condensate. The result is of course practically 100 per cent raw "make-up" for boiler feed with bad scale, forming raw water badly treated, scale and *heavy scale* is inevitable.

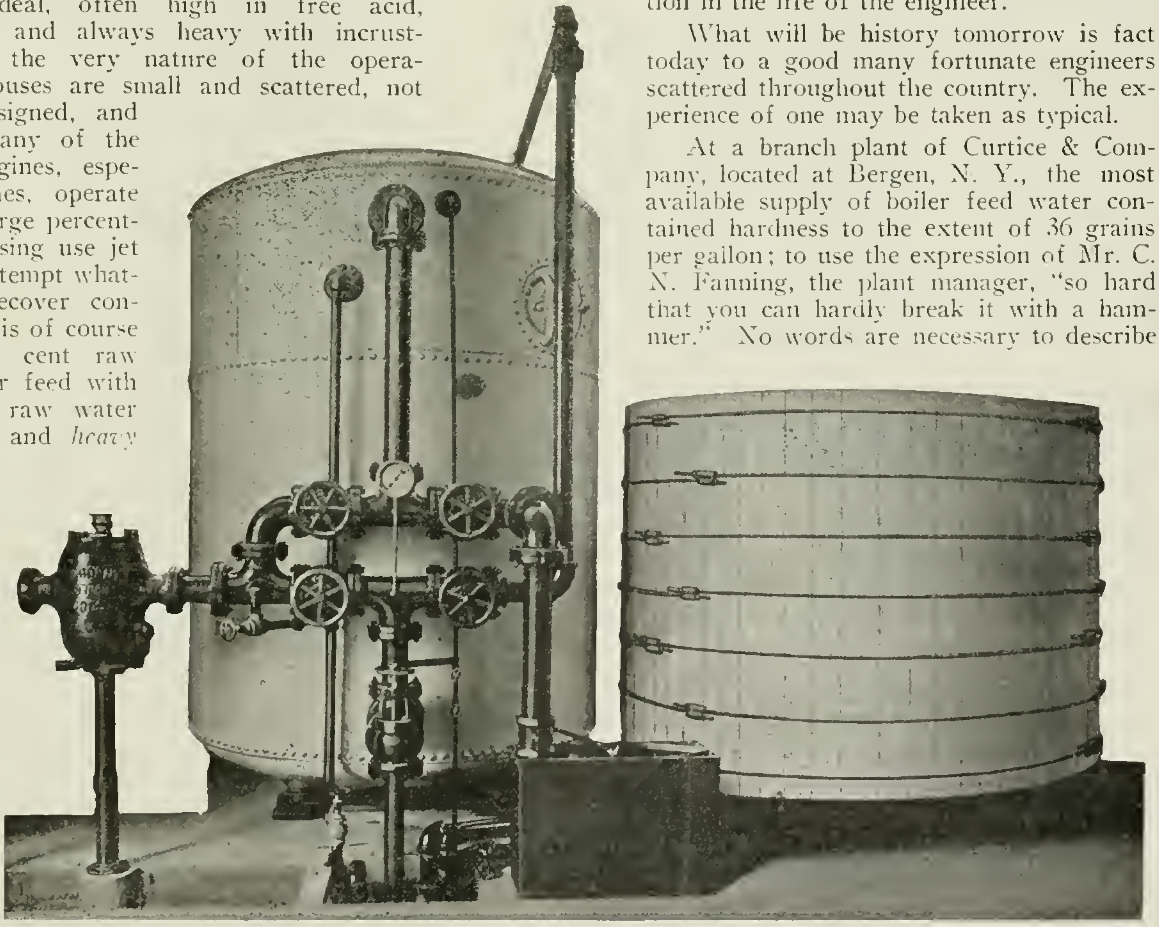
Probably it would take an incalculable figure to express the power losses and power production inflicted by boiler scale in fuel consumption, deficient evaporation, tube replacements and other repairs, cleaning, spare equipment, to allow for idleness during cleaning, extra labor, and so on.

Modern methods have removed the reasons for any toleration of scale formation. Softening water has become a successful art, which places a heavy burden of proof upon the plant which still has recourse to the "hand removal by mechanical cleaner method" of wasteful accumulation of scale. Without quibbling, such a plant is out of date in its methods.

Anyone who challenges the assertion that boiler scale is entirely unnecessary, and can definitely be eliminated, merely acknowledges that he has failed to keep pace with the progress of science, as applied to water purification. There is no longer any more excuse for the presence of scale in a boiler or feed water heater today than there would be for the presence, in the engine room, of the boy who in the early days was employed to jerk the slide valve with a string. That ended when one day a lazy boy hitched the string to the flywheel; the eccentric rod resulted and the boy and his job were forever eliminated. The valve boy is a curiosity today. Boiler scale will be or should be a curiosity tomorrow, something for the historian to write about, but no longer a question in the life of the engineer.

What will be history tomorrow is fact today to a good many fortunate engineers scattered throughout the country. The experience of one may be taken as typical.

At a branch plant of Curtice & Company, located at Bergen, N. Y., the most available supply of boiler feed water contained hardness to the extent of 36 grains per gallon; to use the expression of Mr. C. N. Fanning, the plant manager, "so hard that you can hardly break it with a hammer." No words are necessary to describe



Permutit zeolite water softening system. Showing by-pass valve arrangement and storage tank for zero water.

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*Consulting Engr.

the difficulties of making steam with such raw water. Boilers, heater, piping, valves, pumps and pump-valves, every point in contact with the hot boiler feed was subject to incrustation.

Evaporation results were exactly on a par with the before mentioned conditions, the amount of coal fired was out of all proportion to the steam generated and work done. Although these boilers were in service but a short season during the year, they invariably required retubing annually.

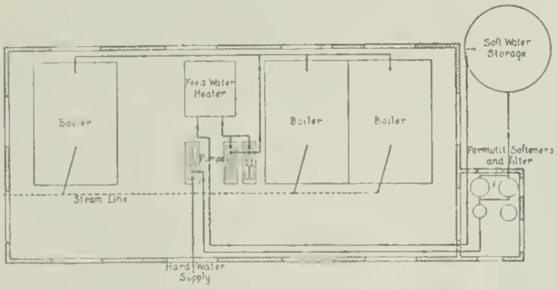
Three years ago a Permutit zeolite water softener, as auxiliary to the feed water system, was installed; since that time all troubles due to boiler water have disappeared, and in three years of operation the boilers have required absolutely no repairs. Recently they were opened for inspection and, in the opinion of Mr Fanning, the boilers could have looked no better if they were new; there was not the slightest evidence of scale.

Incidentally the plant records indicate a saving in coal alone equal to the cost of the Permutit softener.

Zeolites used in water softening are a tri-basic compound, sodium-aluminum-silicate.

Natural zeolites of commercial value for this purpose are found in widely scattered deposits. In general they lack the uniformity and dependability of the manufactured article; synthetic zeolites can be and are made for a great variety of definite purposes.

The essential value of this remarkable product is the unique attribute which it possesses of "exchanging bases," calcium and magnesium for sodium; and, alternately, sodium for calcium and magnesium.



Layout of water softening plant.

Any raw water contaning calcium or magnesium, which form the so-called "hardness" in waters, when brought into contact, by filtration or percolation through a bed of zeolite, will be found to have lost all that "hardness," the sodium of the zeolite, which is soluble and non-incrusting, will have taken the place of the calcium and magnesium.

The zeolite in the filter-bed will have become $\left.\begin{array}{l}\text{Calcium}\\ \text{Magnesium}\end{array}\right\}$ Aluminum, Silicate and the effluent water will be zero soft.

The reverse operation restores the zeolite to its original condition. Sodium, in dilute solution, the ordinary salt of commerce being employed, serves as the re-exchange medium.

The operation of "regeneration," as this re-exchange of base is termed, is entirely mechanical, simplicity itself. No chemicals whatever are used, the time element may be made unimportant, and the results are positive. Very slight loss of zeolite material occurs—that incident to a flushing operation only—and the life of the material seems to be indefinite.

Permutit zeolite water softening plants are in continuous operation under every variety of conditions from the Atlantic to the Pacific. Many installations are giving ideal results where all other methods failed and failed badly. There are no limitations as to size of softening plant, and no limitations as to the daily volume of water which such a plant may be designed and built to handle.

Reference was made in the first paragraph of this article to the power losses and the excessive cost of power production inflicted by boiler scale. Serious as those direct effects are, they do not constitute all, nor indeed the worst, of the waste caused by raw hard water. The decided trend toward larger boiler units, a development which is particularly important in the blast furnace and steel mill industry with its large power units, has magnified these difficulties. One of the reasons for a battery of boilers rather than a single boiler of capacity equal to the aggregate of the battery has been that it was necessary to shut them down, one after another, for cleaning. So long as scale was a "necessary evil," continuity of operation was maintained at the cost of a certain degree of cumbersomeness, appreciable inefficiency and excessive space. It is now possible and economical to eliminate this. With a constantly clean surface on the water side of the metal, with the insulating coat of scale gone, never to return, affording uninterrupted conduction of heat from fire to water, there is never any overheating of the metal, either in tubes or shell, consequently no loss of tubes or drums.

Zero water also does away with foaming. This in turn permits, in most installations, of minor alterations in equipment and operation which further improve duty, as foaming or priming carry in their wake a whole train of undesirable penalties.

The result of all this is that it is nothing unusual for a boiler on zero water to operate at 200 and even 300 per cent of its rated capacity. Boilers are doing that today which previously were unable to deliver 100 per cent of their rating except for a few days immediately after thorough cleaning. The value of this margin of power, gained without the necessity of additional investment in boilers and housing, is obvious. That it does not unduly overload a well made boiler is shown by the strikingly unanimous reports that the need of repairs ceases when the boiler is fed with the kind of water it ought to have, zero water.

THE PRODUCTION OF RUSTLESS IRON

There has been developed recently in England a "rustless iron." This material is iron to which a certain proportion of chromium has been added. A similar alloy called 'stainless steel" has for some time been familiar to metallurgists. Stainless steel differs from rustless iron chiefly in that it contains small amounts of carbon. In order to produce rustless iron, an iron-chromium alloy free from carbon, it is necessary that carbon-free iron and chromium be available. The usual forms of chromium, commercial grades of ferro chromium, contain comparatively large amounts of carbon. The discovery of rustless iron has thus made it very important to be able to treat ferro-chromium by some process which will remove the carbon. Among the methods proposed is that of heating ferro-chromium in contact with hydrogen.

This work is described in Scientific Paper No. 448 of the Bureau of Standards, available from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5c per copy.

WITH THE EQUIPMENT MANUFACTURERS

MOTORBLOC—THE MOTOR DRIVEN CHAIN HOIST

An electrically operated material-handling device, known as the Motorbloc, has been placed on the market by the Motorbloc Corporation of Summerdale, Philadelphia. This new device has been developed to serve the operations lying between the well-defined field of the standard hand chain hoist and that of the traveling electric hoist.

The Motorbloc is a rugged, and readily portable hoist, which can be installed with the facility of an electric drill, and the self-contained pendant controller permits convenient operation as soon as the cord has been plugged into the nearest electric circuit.

Great care has been used in avoiding the stressing of the hoisting mechanism beyond the loads and speeds for which it is proportioned for hand operation.

It consists of a standardized chain hoist of steel construction, electrified by the application of a specially designed heavy-duty motor, liberally proportioned reduction gearing and slip friction clutch, applied by means of a malleable iron supporting bracket comprising a self-contained electrifying unit, to which the pendant controller is also attached. In this way a simple, rugged mechanism has been developed for the electrification of the standard spur-geared chain hoist in capacities ranging from ¼ to 10 tons, proportioned to stand up under the severe overloads and abuse to which portable apparatus of this character is subjected by common labor, generally unfamiliar with the handling of power machinery.

Extreme care has been given to features of compactness, symmetry and balance, combined with lightness and strength through the use of the highest grade materials, liberally proportioned to meet the most severe service conditions. The armature shaft and worm are carried in heavy duty ball-bearings and liberal provision has been made for adequate, automatic lubrication.

The self-contained, pendant controller is easily operated by the fingers of one hand, leaving the other hand free to guide the load. This arrangement makes it possible for one man, without physical effort, to accomplish what would otherwise require two or more men for lifting and placing the same load. The ready portability of the unit is apparent from the fact that the one-ton size complete weighs only 148 pounds.

The extreme simplicity of this mechanism is promoted and the operation safeguarded by the use of the ring-oiled slip friction clutch which prevents damage from over-running to the hoist parts and chain and at the same time completely protects the motor from overload, without the complication of an electric limit switch.

For occasional use at points where electric current is not available, or in the event of the temporary failure of electric power, the hand chain can be quickly applied, and the hoist operated as an ordinary block.

THE NEW HAUCK OIL BURNER

The Hauck Venturi Fuel Oil Burner is a new and improved type of atomizer in which oil or even tar is completely atomized or broken up into finely divided fog-like particles by means of steam or compressed air.

The burner consists essentially of a cylindrical casing with slots parallel to the bore axis. These slots form with the inner wall of the casing longitudinal ports or orifices through which the atomized oil is impelled into the furnace. Each port or orifice is a small Venturi tube constricted at its center and flared outwardly at the two ends. The throats or constricted parts of the orifices are connected with the interior of the bore by means of radial openings or apertures.

The oil or tar is delivered under a pressure of 40 to 60 lbs. per sq. in. to the bore, and then passed through the radial apertures to the orifices where it is collided against and blasted by the compressed air or steam.

The compressed air or steam is delivered to the burner at about 80 to 100 lbs. per sq. in. pressure. As it flows through the ports, its velocity increases rapidly and becomes a maximum at the orifice throats. Here it strikes and blasts the oil, atomizes it thoroughly, even by-product tar, and impels the atomized oil from the burner.

The Hauck Venturi Oil Burner secures a thorough mixture of the air and atomized fuel oil at the mouth of the burner. It is correctly proportioned to the oil and steam or air pressures available, is accessible for purposes of cleaning and inspection, and can be conveniently removed from the furnace without affecting the operation of any other burner served by the same piping system.

Reducing, neutral and oxidizing flames are readily obtained merely by manipulating the oil and air valves. The furnace atmosphere is thus closely controlled.

Combustion can be made to take place close to the burner nozzle. Oxygen consequently cannot come into contact with the steel. This results in less scaling. Decarburizing of the work is reduced, and there is less spoilage and greater uniformity of product.

Close control of temperature is accomplished with ease and certainty. The temperature of the furnace is controlled through two standard valves. The labor and attention required are a minimum.

Uniform combustion conditions and ready, exact and simple temperature control increase the efficiency of production. Fewer demands are made upon skill and judgment in the handling of the furnace, and more time and attention can be devoted to the work itself.

The Hauck Venturi Oil Burner is simple to install and easy to operate. The efficiency of the burner is high. It is adaptable to a wide range of work, including the following:

Baking, bolt heading, bluing, carburizing or case-hardening, continuous reheating, core ovens, drying, enameling, forging, galvanizing, hardening, japanning, ladle drying, lead and cyanide pot furnaces, melting furaces with crucibles, melting furnaces without crucibles, muffle and retort furnaces, nonferrous and precious metal melting, oil tempering baths, open hearth furnaces, plate, angle and rod heating; rivet forges, scrap reclaiming, soaking pits, soft metal melting, tinning wire, strip and sheet, tool dressing, tube brazing, vitrious enamel melting, welding.

NEWS OF THE PLANTS

Power Specialty Company, builders of Foster superheaters, economizers and oil heating and cooling equipment, announces the opening of new branch offices. Mr. L. Lanyi is to be in charge of the office at Dime Savings Bank Building, Detroit, Mich., and Mr. R. B. Nutting, who was formerly Chicago district manager, in charge of office at 2324 Fourteenth Street, Boulder, Colo.

The Guilbert Steel Company, Diamond Bank Building, Pittsburgh, Pa., recently organized under state laws, has acquired property in the West Park district for the construction of a new plant for the manufacture of steel products including a general fabricating works. Plans will be prepared at once for the initial buildings, to comprise a main one-story structure, 50x200 feet, to cost approximately $100,000, with machinery. The new company is headed by O. E. Guilbert and R. C. Stewart. It is represented by John Rebman, Jr., 43 Nicholas Building, Pittsburgh.

George M. Thompson, West Newton, Mass., formerly vice president and general manager of the Wickwire Spencer Steel Corporation, Worcester, Mass., is organizing a new company to manufacture a line of steel products and operate a rolling mill. Plans have been prepared for the construction of the proposed plant on site at 41 Mildred Avenue, Dorchester, Mass. The rolling mill will be 60x115 feet, and supplemented by two other structures 50x150 feet and 25x35 feet, each one-story. It is purposed to have the plant ready for service at an early date. Brainard, Leeds & Kellogg, 89 Franklin Street, Boston, Mass., are architects.

The Southern Sheet Steel Company, Chattanooga, Tenn., recently organized, has plans in progress for the construction of a new local plant, designed to manufacture sheet steel, 12-gauge and smaller. The initial works will consist of an eight-sheet rolling mill and three open-hearth furnaces, each with capacity of about 60 tons. It is expected to give employment to a working force of about 700 men when operating at capacity, with estimated output of close to 55,000 tons per annum. The entire works will cost in excess of $1,200,000, with machinery. W. M. Bleckner is president; and W. J. Lynch, vice president in charge of operations. Equipment purchases will be made at an early date under the direction of the last noted official.

The American Rolling Mill Company, Middletown, Ohio, has plans nearing completion and will soon break ground for the construction of additions to its plant at Ashland, Ky., to provide for a complete system of blast and open hearth furnaces, blooming mill, sheet and finishing mill and miscellaneous structures for the production of general commercial steel products. The new structures will consist of a one-story sheet mill, one-story jobbing mill, and one-story galvanizing plant, estimated to cost approximately $250,000, with machinery. Dwight P. Robinson & Company, Inc., 152 East Forty-sixth Street, New York, N. Y., is engineer and contractor in charge.

The Bethlehem Steel Corporation, Bethlehem, Pa., has plans in progress for extensions and improvements at its Lackawanna Steel Works, Buffalo, N. Y., recently acquired, and will arrange a fund of about $15,000,000 for the expansion. The plant will be remodeled and modernized and considerable new machinery installed in the different operating departments. The capacity will be considerably increased. The company is advancing production at its Bethlehem works as well as at its plant at Steelton, near Harrisburg, Pa. A number of operating units at the last noted plant have been placed in service after an inactivity of more than a year.

The Empire Drawn Steel Company, 1133 Marine Bank Building, Buffalo, N. Y., is completing plans for the construction of a new local plant on Germania Street, for the manufacture of cold drawn steel products, and other steel specialties. The main structure will be one-story, 75x450 feet, and is to be equipped for an initial output of approximately 35,000 tons per annum. It is estimated to cost upwards of $100,000. Work will be placed under way at an early date.

The New Process Steel Company, Noblesville, Ind., is completing the construction of the initial units at its new local plant, and will commence immediate production at a portion of the works. The company will specialize in the manufacture of steel billets, small-sized T-rails, and structural steel shapes. The entire works is expected to be ready for service early in the coming year, and production will be advanced at that time to include a working force of more than 2,000 men, on a full-time working basis. J. F. Reiner is president of the company; J. E. Owen, vice president, and James Hundley general manager.

The National Enamel & Stamping Company, 411 Fifth Avenue, New York, N. Y., has foundation work in progress for the new sheet mill at its plant at Granite City, Ill. Plans for the superstructure have been completed, and it is proposed to push the erection to consummation at the earliest date. It is estimated to cost approximately $1,000,000, including machinery.

The Andrews Wire & Iron Works, 1802 Preston Street, Rockford, Ill., manufacturers of steel and iron products, has plans in progress for the construction of a new plant addition for general increase in capacity, to be one-story, and estimated to cost approximately $50,000. Peterson & Johnson, 406 S. A. Bank Building, Rockford, are architects.

The Columbia Steel Company, Elyria, Ohio, has been reorganized and succeeded by a new company of the same name, formed under state laws, with a capital of $1,500,000. Plans are under way for a number of improvements in the works, to include the installation of perfected processes of manufacture, and considerable new equipment for projected expansion. To provide for the work a preferred stock issue of $500,000 is being arranged. C. E. Lozier, heretofore vice president and general manager of the company, has been elected chairman of the board; H. M. Naugle is president; K. R. Jenson, secretary and treasurer; and A. J. Townsend, vice president, in charge of operations.

The Lukens Steel Company, Coatesville, Pa., manufacturers of steel plate, etc., have acquired property on the Industrial Canal at New Orleans, La., as a site for a new branch plant. Preliminary plans are under way for a complete fabricating works to consist of four units, 75x250 feet, estimated to cost approximately $300,000. A large warehouse building will also be built for immediate service.

THIS

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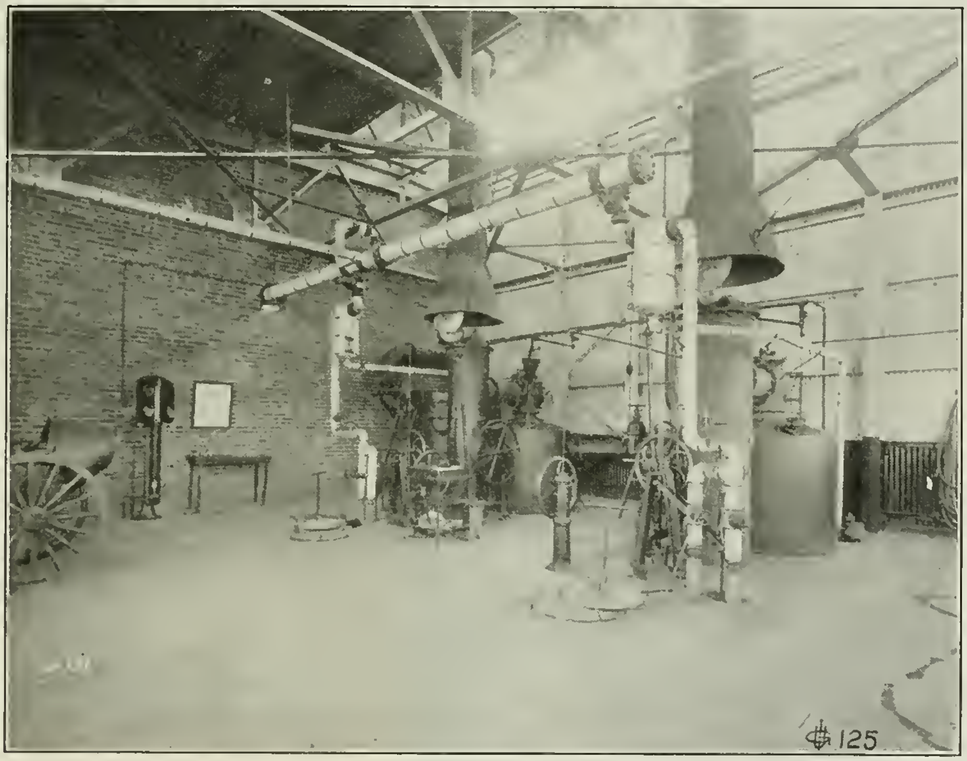
IS LOCATED AT THE

BLAW-KNOX COMPANY'S PLANT

ITS PRODUCT IS BEING SUCCESSFULLY USED FOR MANY INDUSTRIAL PURPOSES



U. G. I. BLUE GAS PLANTS

CAN BE BUILT IN LARGE OR SMALL CAPACITIES AND PRODUCE A CLEAN, COOL GAS OF HIGH FLAME TEMPERATURE

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THE U. G. I. CONTRACTING CO.

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335 Peoples Gas Bldg., Chicago

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COMPANY MEMBER OF AMERICAN GAS ASSOCIATION INCORPORATED 1918

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IT HAS NO EQUAL

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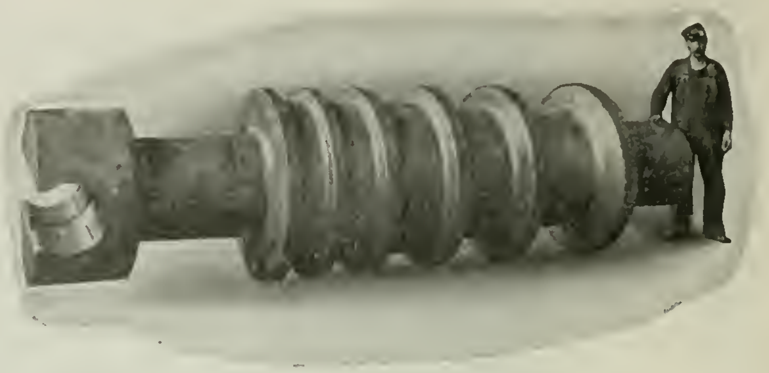

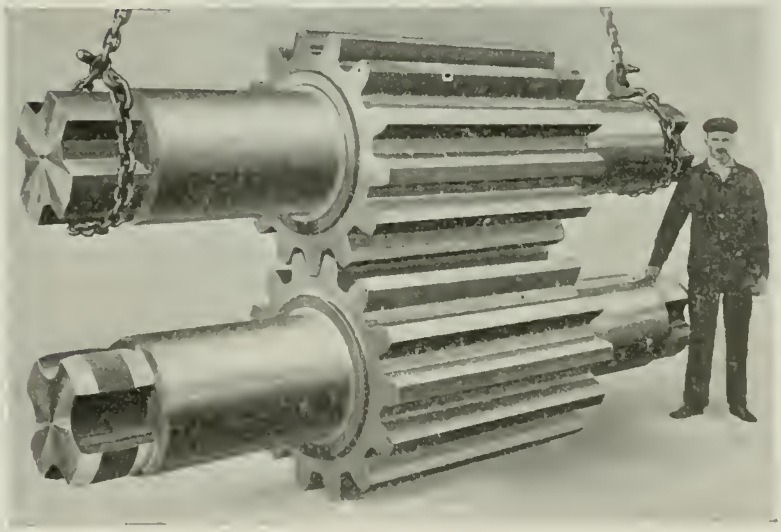

"MESTA SPECIAL" is an
ALLOY STEEL

of high carbon-chrome-nickel composition. Heat treated by a scientific process that produces a combination of

HARDNESS and STRENGTH

not found in any other material used

FOR HEAVY CASTINGS

MESTA MACHINE CO.

CHICAGO
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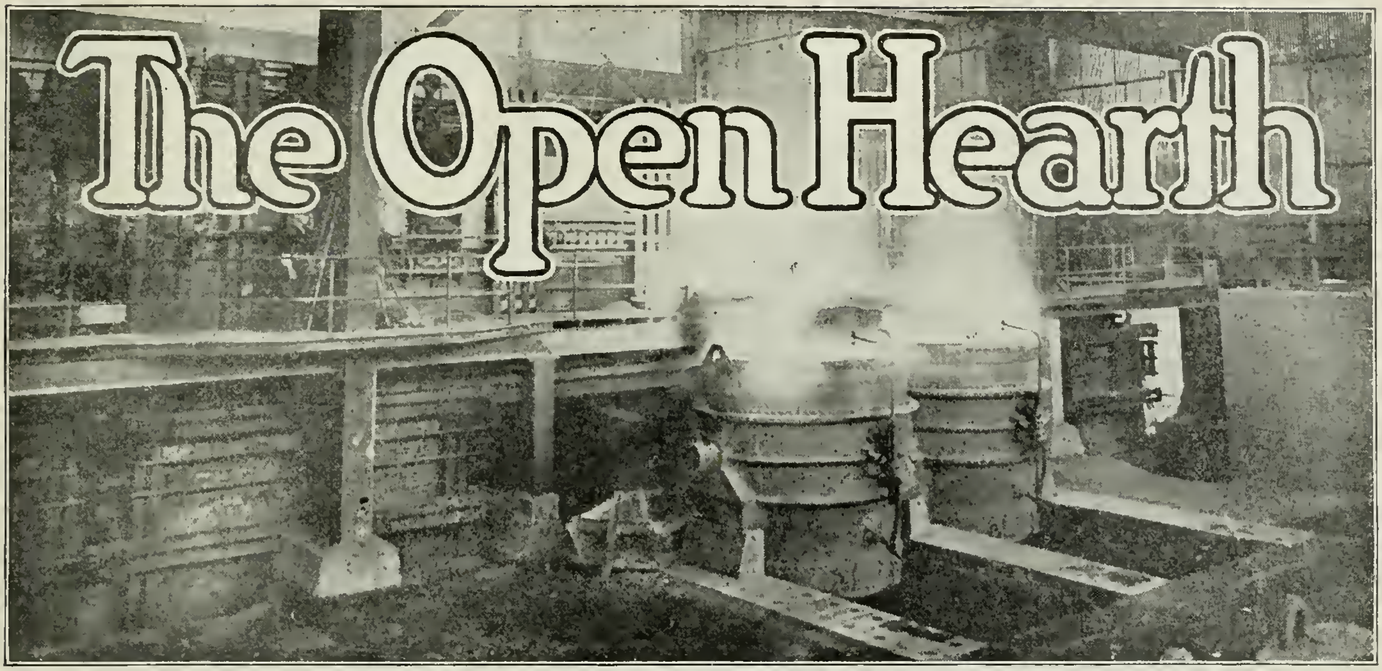
Oliver Bldg.

WASHINGTON, D. C.
Munsey Bldg.

The Open Hearth



Carl G. Schluederberg, assistant to the managers of the Supply and Merchandising Departments of the Westinghouse Electric & Manufacturing Company and special representative of that company in foreign countries, left recently for a four months' trip in the Orient to study business conditions there. Mr. Schluederberg will visit Japan, the Philippines and China to make a sales survey, investigating especially the possibilities of expansion of the market for household appliances. Mr. Schluderberg is well known in American electro-chemical circles and has held various important offices in the American Electro-Chemical Society. He graduated from the School of Electrical Engineering of Cornell University in 1902, and in that year entered the employ of the Westinghouse Electric & Manufacturing Company. In 1905 he took up research work along electro-chemical lines and also entered upon postgraduate work at Cornell University, which he continued until 1908, when he was awarded the degree of Doctor of Philosophy and a degree in chemistry. He also spent some time abroad on special investigations and subsequently became associated with the Carnegie Steel Company and later the United Coal Company in metallurgical and electrical engineering work.

√ √

M. W. Hall, chief mechanical engineer, South Side Works, Jones & Laughlin Steel Company, Pittsburgh, recently resigned and has been succeeded by C. G. Bigelow, formerly with the American Sheet & Tin Plate Company.

√ √

Harry W. Coffin, vice president and general manager, Alabama Company, Birmingham, Ala., retired, effective November 15. John W. Porter, vice president and sales manager, who has been with the Alabama Company for 14 years, will assume Mr. Coffin's duties in addition to his own.

√ √

Harry J. Cogswell, formerly associated with the Ajax Forge Company, Chicago, recently joined the organization of the Valley Forge Steel & Tool Company, Chicago, as general sales manager.

√ √

Joseph G. Shryock, designing engineer, Belmont Iron Works, Philadelphia, Pa., has been appointed chief engineer of that company

√ √

W. W. Heylmun, formerly chief chemist of the St. Louis Coke & Chemical Company, Granite City, Ill., has been appointed blast furnace superintendent, succeeding T. W. Harris, who resigned recently to become connected with the Tata Iron & Steel Company of India.

√ √

Fred C. Severin and B. H. Tripp have formed a partnership for the purpose of buying and selling used machine tools. They have taken an office at 25 Church Street, New York Mr. Severin was for many years with the Niles-Bement-Pond Company and more recently with the Betts Machine Company, Rochester, N. Y., now a part of the Consolidated Machine Tool Corporation, and Mr. Tripp was for many years connected with the Chicago Pneumatic Tool Company.

√ √

R. L. Bears, who has just been appointed chief engineer of the Detroit Stoker Company, graduated from Syracuse University in the 1912 class in Mechanical Engineering. Leaving the university, he spent four years with the United States Bureau of Mines under Mr. O. P. Hood, doing research and testing work on various fuels and combustion apparatus. Four years ago he was appointed testing engineer of the Underfeed Stoker Company of America and was later promoted to the position of assistant chief engineer.

√ √

F. F. Rohrer, assistant to manager of both the Power and Railway Departments of the Westinghouse Electric & Manufacturing Company, has been appointed general contract manager of that company. In his new appointment, which is effective immediately, Mr. Rohrer will be a member of the staff of W. S. Rugg, general sales manager.

√ √

W. W. Sayers, of the Link Belt Company, has been appointed chief engineer of the Company's Philadelphia Works and eastern operations. Mr. Sayers was representative of the company in their Chicago territory in the lines related to power house machinery, coal storage, Peck carriers, crushers, etc., and later in charge of the Locomotive Crane Department

√ √

John K. Boll, for many years sales manager, Page Steel & Wire Company, has resigned to accept an important position with the Wheeling Steel Products Company, which will sell the output of the new rod and wire mills of the Whitaker Glessner Company, now nearing completion at Portsmouth, Ohio. Mr. Boll assumed his new duties November 16.

The Open Hearth

William H. Blount, superintendent Sleeper & Hartley, Inc., Worcester, Mass., wire drawing machinery, has resigned for the purpose of devoting his entire attention to the affairs of the Arey & Blount Electric Company, recently organized to manufacture electric flashlights.

√ √

H. B. Bole resigned as first vice president of the Hydraulic Steel Company, Cleveland, Ohio, at the annual meeting on October 27. He will remain as a member of the board of directors.

√ √

B. F. Phillopon, president Climax Molybdenum Company, 61 Broadway, New York, sailed on the Majestic on October 29 for France, where he will spend four or five weeks on business.

√ √

G. Ernest Wells, director Edgar Allen & Company, Ltd., Sheffield, Eng., is in the United States visiting the western and eastern offices of the Edgar Allen Steel Company, Inc., 86 John Street, New York

√ √

Wm. H. Warren, formerly general manager of Brier Hill Steel Company, Youngstown, Ohio, and previously with the Gary Works of the United States Steel Corporation, has been appointed general manager of the Trumbull Steel Company, Warren, Ohio.

√ √

Charles E. Beeson, who on November 1 was elected a vice president of the Pittsburgh Steel Company, has been identified with that company since its organization in 1901, having been its first secretary and holding that office until about two years ago. For the past three years Mr. Beeson has been a director and a member of the executive committee.

√ √

Stephen Badlam has been appointed works manager of the Superior Steel Corporation, Pittsburgh, the plant of which is at Carnegie, Pa., succeeding James Warren, who resigned recently to become works manager of the LaLance & Grosjean Mfg. Company, Woodhaven L. I. For the past year Mr. Badlam has been engaged as an engineer specializing in rolling mill equipment in Philadelphia, but previously for 12 years had been in the operating department of the Pennsylvania Steel Company; served as assistant chief engineer, Pittsburgh Crucible Steel Company during the building of its plant at Midland, Pa., and later was chief engineer, Pittsburgh Seamless Tube Company, Beaver Falls, Pa. In the World War, he was major of infantry on the general staff, First Army, and was overseas for two years. Following the war he was sales engineer with the Philadelphia Roll & Machine Company. He is a graduate of Massachusetts Institute of Technology.

√ √

Willis L. King, vice president, Jones & Laughlin Steel Company, Pittsburgh, has returned to his desk after an absence of several weeks due to illness, which also prevented his attendance at the recent meeting of the American Iron and Steel Institute, of which he is a vice president. Mr King on July 12 last rounded out 53 years with the Jones & Laughlin Steel Company

√ √

P. D. Brown has been appointed district sales manager in southern territory of the Polidi Steel Corporation of America, with headquarters at Baltimore. Mr. Brown was formerly general manager of the Lakeside Forge Company, Erie, Pa.

√ √

C. V. Dodge, formerly in charge of steel casting sales for the United Engineering & Foundry Company, Pittsburgh, has been promoted to assistant manager in charge of roll and steel sales. He began his career with the company in 1904 as shipping clerk at the steel foundry in Vandergrift, Pa, and was later made foreman of the chipping shop at this plant. In 1916, he was given charge of steel casting sales.

√ √

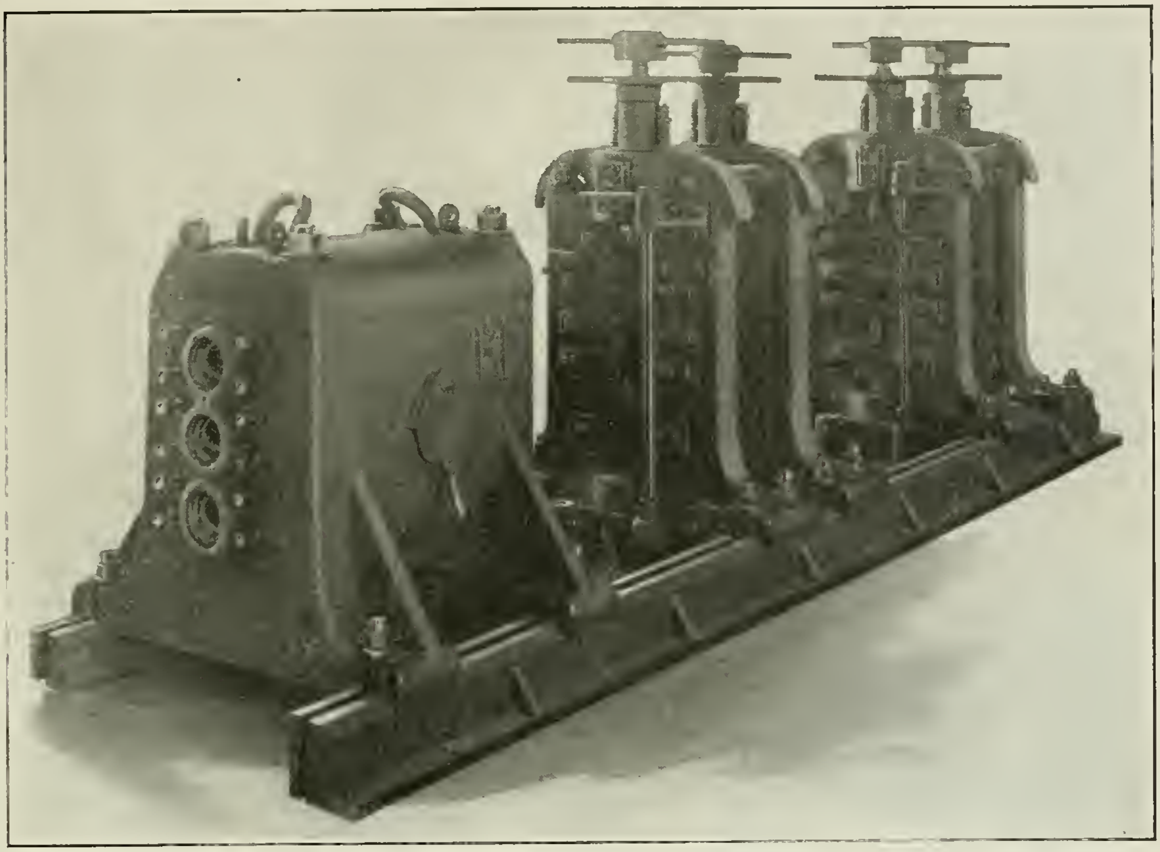
John Duncan, president Illinois Company, St. Louis, Mo., and formerly president of the Wheeling Steel & Iron Company, has been elected a director of the National Enameling & Stamping Company.

√ √

J. J. Stoddard has been appointed general manager of the Lakeside Forge Company, Erie, Pa., manufacturers of drop forged wrenches and forgings. Since the first of the year he has held the position of sales manager.

√ √

A. H. Hunter of Buffalo has resigned as president of the Atlas Steel Corporation, Dunkirk, N. Y., a consolidation of the Atlas Crucible Steel Company of Dunkirk and the Electric Alloy Steel Company, Youngstown, Ohio. Mr. Hunter was formerly president of the Atlas Crucible Company. The position will remain vacant and the duties of president will be performed by L. J. Campbell chairman of the board in immediate charge of the company. Mr. Campbell was previously president of the Electric Alloy Company.



FOR SALE

NEW 8" ROLLING MILL

Two Stands—Three High

Comprising very latest type housings—top and bottom screws, etc.; pinions totally enclosed. Double helical cut teeth, running in oil.

READY FOR IMMEDIATE SHIPMENT

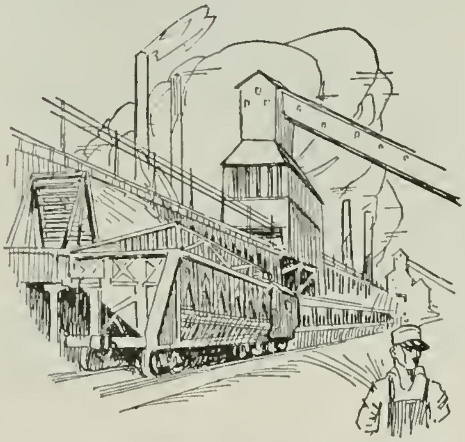
Full Information and Inspection on request.

MACKINTOSH-HEMPHILL CO.

Fort Pitt Foundry **PITTSBURGH, PA.** Woodward Machine Co.

A Garrison Foundry—Pittsburgh Iron & Steel Foundry

The Koppers Company's New Oven



Fifteen Years Ago—the by-product coke oven industry received an impetus from the introduction of a new oven that has carried it from comparative obscurity to a point where it is now recognized as one of the basic industries of the country.

Through its development, coal products worth billions of dollars have been saved and utilized for the benefit of the nation, creating new industries and broadening the scope of others.

The part played by the Koppers Company in this development is best expressed by the fact that out of a total of 9,300 ovens built in the United States and Canada since 1903, when the first Koppers Ovens were built, 7,196, or 88%, have been designed and built by this company.

Today—the Koppers Company's New Oven gives an even greater conception of the benefits to be derived from the by-product coke oven, establishing a standard of performance that far excels anything heretofore attained.

There are now built or building 408 ovens of this new design, as follows:

Chicago By-Product Coke Co., Chicago, Ill.	5
Carnegie Steel Co., Clairton, Pa.	366
Weirton Steel Co., Weirton, W. Va.	37
Total	408

The Koppers Company
PITTSBURGH, PA.

Some Pointers on By-Product Coke Oven Operations

COMBUSTIBILITY OF COKE

Further work on the combustibility of coke and relative re-activity with carbon dioxide is being conducted by the southern experiment station of the United States Bureau of Mines, Birmingham-Tuscaloosa, Ala., in co-operation with the Pittsburgh, Pa., station of the bureau. Two variable properties of coke, namely, its combustibility and rate of oxidation of "solution" in carbon dioxide, are believed to play an important part in its performance in the blast furnace. It has been stated that the ideal coke should come down to the tuyere zone without oxidation by the carbon dioxide in the stack gases (Gruner's ideal working) and should there burn rapidly to carbon monoxide. Laboratory scale tests for determining relative combustibility of cokes and their reactivity with carbon dioxide have been developed and a number of by-product and beehive cokes tested. The relation between these values and the physical properties of the coke has been studied. A comparison of laboratory scale test results and results of actual furnace practice is being made.

DETERMINES ASH IN COAL WITH MILK TESTER

A. M. Rogers, a research worker in the School of Mines at the Pennsylvania State College, has devised a novel scheme for estimating rapidly the percentage of ash likely to be contained in a given sample of coal. By means of a centrifuge such as is used to test the proportion of cream in a given sample of milk, he has succeeded in making tests of coal in a few minutes whereas the previous method, which necessitated the burning of the coal, took nearly a day.

The coal to be tested is ground finely and poured into test tubes containing a liquid. When the tubes are whirled around rapidly by the centrifuge, the slate and sulphur go to the end of the tube and the combustible part of the coal is left near the top. Graduations, like those used in the milk and cream tester, show at once the proportion of waste in the coal.

TO CLOSE GAP IN BY-PRODUCT COKE STATISTICS

The U. S. Geological Survey has recently been getting a monthly report of by-product coke output corresponding to the reports received during the war. However, figures have not been available for 1919 and 1920 and the survey is now planning to get these data so that there will be a continuity of record from 1917 on.

The survey is urging co-operation of the industry in this matter. It is recognized that the data are of very great industrial significance not only in the coke industry itself but also to metallurgical industries and fuel users generally. An early summary of the data is promised if prompt reply is received by the survey.

TESTING MATERIALS SOCIETY DEFINES COKE*

In order to standardize the methods of testing coke and to give it a nomenclature which will be of nation-wide acceptance, the Society for Testing Materials, in its annual volume of tentative standards, has included a chapter entitled "Tentative Definitions of Terms Relating to Coke." It defines coke, beehive coke, by-product coke and gashouse coke.

Foundry coke from beehive ovens it designates as coke which is physically and chemically suitable for use in foundry cupola practice. It may be either 72 or 48-hour coke. The principal difference between the two is the greater size of the 72-hour coke, due to thicker coal beds employed in its preparation. The breeze, or fine coke—smaller than approximately ¾-in.—is forked or screened out.

Foundry coke from by-product ovens is coke that is physically suitable for foundry cupola practice and which passes over a screening device having approximately 2½ in. openings. It is not produced in any standard coking time.

Furnace coke from beehive ovens is coke that is physically and chemically suitable for the reduction of iron ore in blast furnaces. The breeze smaller than approximately ¾-in., as in foundry coke from the same source, is forked or screened out. The usual coking time is four 48-hour charges and two 72-hour charges.

Furnace coke from by-product ovens is coke that is physically and chemically suitable for the reduction of iron ore in blast furnaces and which passes over a screening device with openings varying from ¾ in. to 1½ in., depending on local conditions at different plants. It is not produced in any standard coking time.

Domestic coke is coke of the smaller screened sizes, below approximately 2½ in., suitable for use in domestic stoves, heaters, etc. The standard sizes are quite generally sold under the names given in the table and the screened sizes are average, although locally varied somewhat.

USUAL SIZES OF DOMESTIC COKE

Name	Size of Screen Passing	Size of Screen Retained
Egg	2½ In.	1¾ In.
Stove	1¾ "	1¼ "
Nut	1¼ "	¾ "
Pea	¾ "	½ "
Breeze	½ "	..

The chapter also defines for purposes of analysis dry coke, moisture, ash, volatile matter and fixed carbon. Volatile matter is described as that part of coal or coke which on heating is driven off in the form of tars and gases and is determined as the percentage loss in weight, less the percentage of moisture, sustained on heating coke in a covered platinum crucible for seven minutes at a temperature of 950 deg. C.

Obviously coal should be omitted in the first part of this definition if it is not to be placed in the last part. Certainly all the volatile matter driven off dry coal does not consist of tars and gases unless steam is regarded as a gas, which indeed it is, but it would seem that the words were put in purposely to exclude steam, for if it does not exclude it these words are entirely useless. The definition is faulty and misleading.

Dry coke is defined as coke which has been dried to constant weight at temperatures not less than 104 deg. C. nor more than 200 deg. C. in the case of lump coal and between 104 deg. C. and 110 deg. C. in the case of 60-mesh coke. This also is not as specific as it with advantages might be made. Why leave a range as great as that between 104 and 200 deg. C.?

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*From Coal Age, November 23.

TRADE PUBLICATIONS

TRADE PUBLICATIONS

Steel Conveyors — Sandvik Steel, Inc., 233 Broadway, N. Y., has issued Catalog No. 18 which contains information on the application of the steel belt in conveying problems, also as to its efficiency and economy. Illustrations are supplemented with fractional views of various units in the construction. The booket contains 2 pages.

Alloy Steels — The Central Steel Company, Massillon, Ohio, has issued a 44-page booklet giving a brief story of the evolution of the alloy steel industry, and listing many parts for which alloy steels are used. Numerous charts are included giving chemical and physical characteristics of many most generally used alloy steels. Specifications are also given of some of the special alloy steels made by this company.

Combustion Device — Crown Fuel Saver Company, Richmond, Ind., recently issued an illustrated circular describing a device for introducing supplementary air for combustion immediately above the fuel bed of coal-burning furnaces. Earl F. Whitaker, 30 Church Street, New York, is agent.

The **Century Electric Company**, St. Louis, Mo., have issued four booklets in which many types of motors are described and illustrated. One bulletin is devoted to repulsion start induction single phase motors; a second to automatic start induction poly-phase motors; a third to split phase induction motors and the fourth to squirrel cage induction polyphase motors.

Stokers — The Laclede-Christy Clay Products Company, St. Louis, is circulating a bulletin describing Armour & Company's experience with their stokers. The bulletin is well written and illustrated, and gives much data of value to prospective stoker buyers.

The **U. G. I. Contracting Company**, of Philadelphia, has recently been awarded a number of contracts. They will install an additional carburetted water gas apparatus for the Roanoke Gas Light Company, Roanoke, Va., and will remodel and improve the carburetted water gas sets of the C. H. Geist Company, Glassboro, N. J., and the two sets of the Lewiston Gas Light Company, Lewiston, Me. The Old Colony Gas Company, East Braintree, Mass., has also decided upon extensive improvements to its plant, which will be carried on by the U. G. I. Company. The Queens Borough Gas & Electric Company will have improvements made on an extensive scale; and the Equitable Gas Company of Pittsburgh has made arrangements for the installation of three U. G. I. automatic controls at its Elrama plant.

TRADE NOTES

NEW SHEET MILL SHEARS

The Youngstown Foundry & Machine Company, Youngstown, Ohio, builders of mill machinery, have recently added to their line a complete set of heavy squaring shears for sheet mills, embodying the latest features of design and construction. These machines are built in 72, 108, 126 and 154-in. sizes. This company has also recently developed a sectional angle straightening machine so constructed that it may be furnished with 7, 8, 9, 11 or 13 rolls as desired. These machines are so built that the number of rolls may be increased readily by the addition of further sections. This feature will undoubtedly prove to be a great advantage over the old type of straightening machine in common use.

WESTINGHOUSE COMPANY MAKES RECORD SHIPMENT OF ELECTRIC LOCOMOTIVES

The third shipment of electrical equipment for the Chilean State Railway, consisting of six complete electric locomotives, the largest shipment of electric locomotives ever made, recently left the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company. The shipment was valued at $700,000 and represented a partial fulfillment of the $7,000,000 contract awarded the Westinghouse International Company by the Chilean State Railways.

Thirty-nine electric locomotives, 15 for road freight service, six for express passenger service, 11 for local passenger service and seven for switching service, are to be built by the Westinghouse Company for the Chilean Railways. The six locomotives in the recent shipment are of the road freight type and weigh approximately 103 metric tons each. They are capable of maintaining an average speed of 35 miles per hour when hauling a 770-ton train on any part of the line between Valparaiso and Santiago, except the heavy Tabon grade.

Freyn, Brassert & Company, Chicago, have recently taken contracts with the Norton Iron Works, Ashland, Ky., for the relining of one of their hot blast stoves with the Brassert Patented Hot Blast Stove Lining, also with the Belfont Iron Works Company, Ironton, Ohio, for installation of a pig casting machine at their furnace plant."

Dayton Steel Foundry Company, Dayton, Ohio, have just purchased a three-ton Moore Rapid 'Lectromelt furnace for their steel foundry. Their trade has enlarged to the extent that their old furnace equipment will not take care of it and the company is improving its equipment in view of its larger business. The 'Lectromelt furnace here replaces two furnaces of another make.

Freyn, Brassert & Company have recently contracted for installation of patented Bacon Waste Heat Boilers at the Bettendorf Company, Bettendorf, Iowa, and at the plant of the Carpenter Steel Company, Reading, Pa.

The Norwalk Iron Works Company, pioneer builders of compressors, manufacturing air and gas compressors for all purposes and also refrigerating machinery, with general offices and works, South Norwalk, Conn., has just opened a Chicago office. It is located at 627 W. Washington Boulevard and is in charge of Mr. L. R. Bremser who for 13 years was associated with the Gardner Governor Company. He is thoroughly familiar with all angles of the compressor business.

The Underfeed Stoker Company of America has received orders from the National Enameling & Stamping Company for all the sheet, pair, and annealing furnaces for their new plant at Granite City, Ill. The same company has received an order from the Newton Steel Company, Newton, Ohio, for a pair furnace for their new plant.

Work has been started by Dwight P. Robinson & Company on the design and construction of an extension to the plant of the American Rolling Mill Company at Ashland, Ky. The extension will include a jobbing and sheet mill, and a galvanizing plant. This is one of several undertakings recently awarded to Dwight P. Robinson & Company.

COMING MEETINGS

December 4-8 — American Society of Mechanical Engineering, annual meeting in Engineering Societies Building, New York. Calvin W. Rice, 29 West 39th Street, is Secretary.

December 7-13 — National Exposition of Power and Mechanical Engineering at the Grand Central Palace, New York.

January 11-12—American Engineering Council annual meeting headquarters F. A. E. S., 24 Jackson Place, Washington. L. W. Wallace, 24 Jackson Place, Washington, is Secretary.

February 17-22 — Universal Exposition of Inventions and Patents, under the auspices of the Universal Patent Exposition Corporation, Grand Central Palace, New York.

February 19-21 — American Institute of Mining and Metallurgical Engineers annual meeting in Engineering Societies Building, New York. F. F. Sharpless, 29 West 39th Street, is Secretary.

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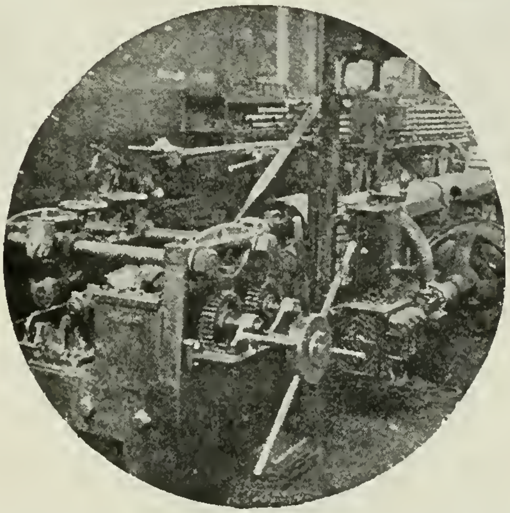

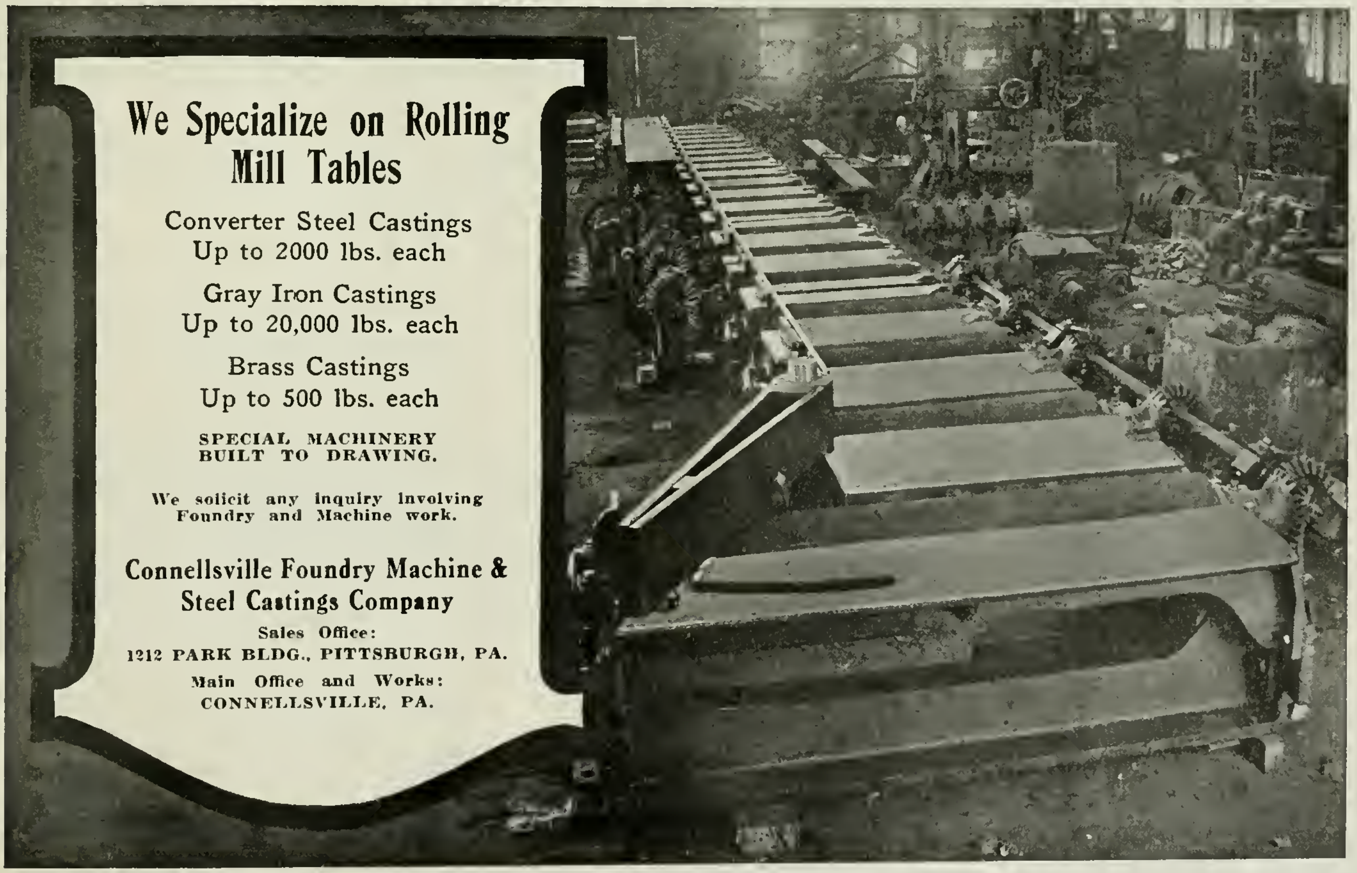

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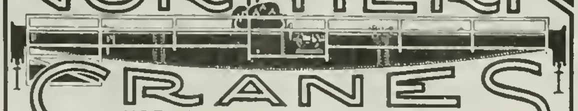

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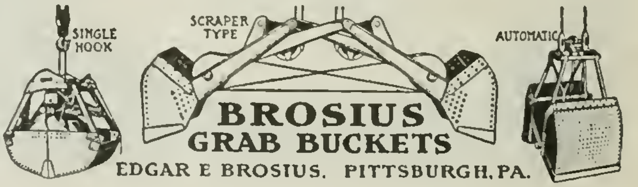

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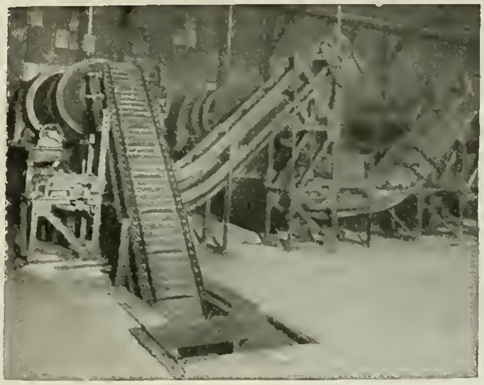

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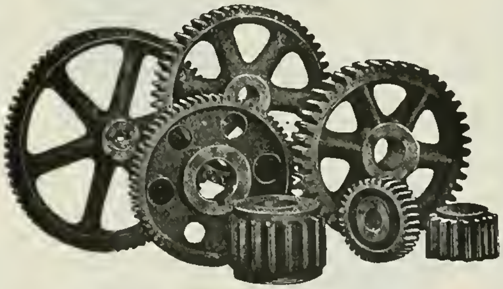

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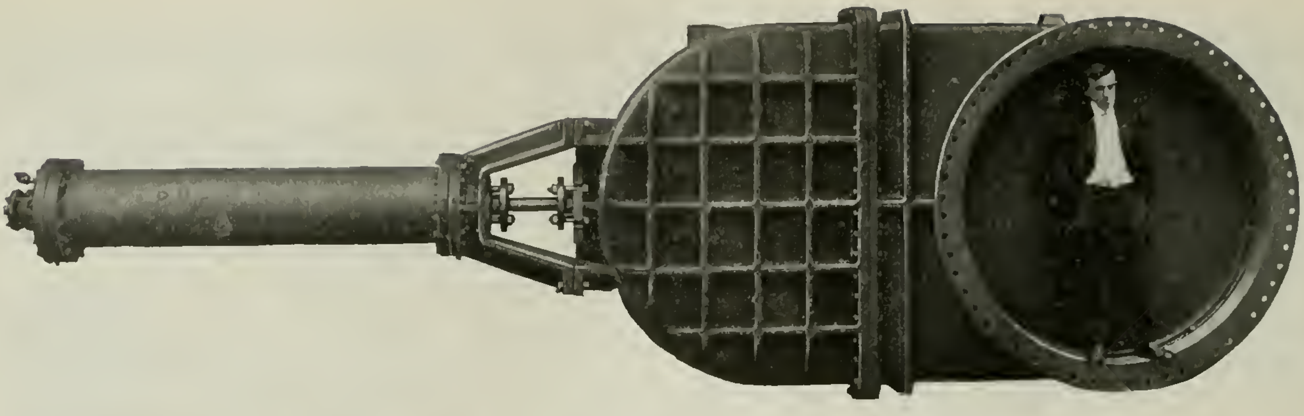

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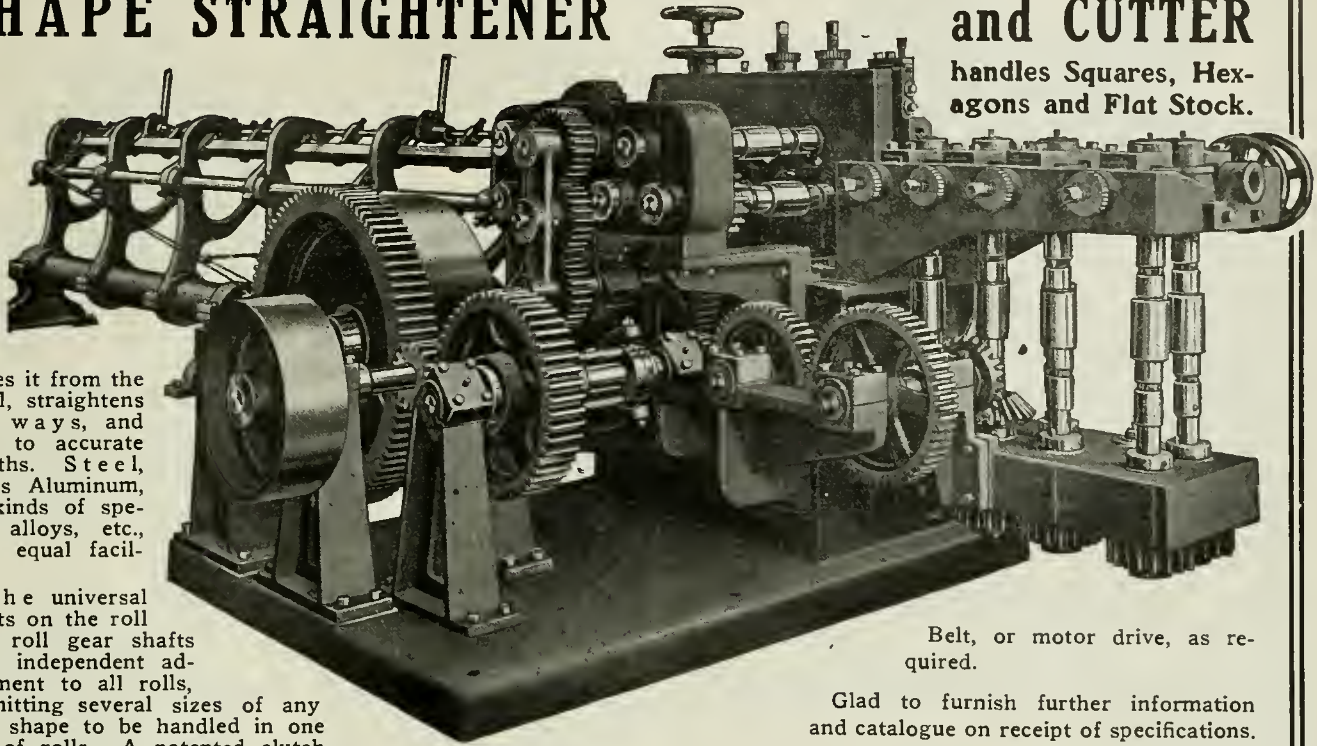

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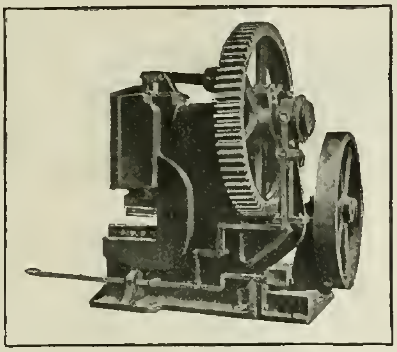

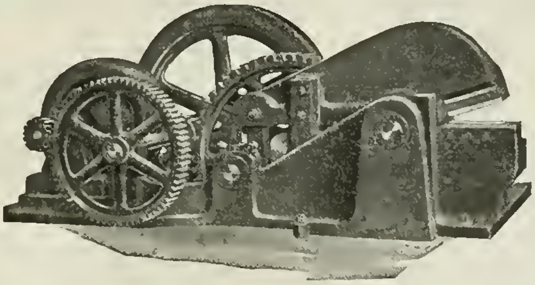

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Clark Car Co.

Cars—Hot Metal.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Youngstown Fdy. & Mch. Co.

Cars—Scale and Transfer.
Arthur G. McKee & Co.

Cars—Slag.
Birdsboro Steel Fdy. & Mch. Co.

Cars—Industrial.
Youngstown Fdy. & Mch. Co.

Cars—Ingot, Open Hearth, Charging.
Mesta Machine Co.

Cars—Ladle Transfer.
Youngstown Fdy. & Mch. Co.

Car Tanks.
Blaw-Knox Co.
Kellogg, M. W. Co., The

Cartridge Fuses—Renewable and Non-Renewable.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Castings.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Mesta Machine Co.

Castings—Brass.
Connellsville Fdry. Mach. & Steel Casting Co.
Lawrenceville Bronze Co.

Castings—Brass and Bronze.
Lawrenceville Bronze Co.
Mesta Machine Co.

Castings—Copper.
Lawrenceville Bronze Co.

Castings—Electric Steel.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Wheeling Mold & Foundry Co.

Castings—Gear.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Connellsville Fdry. Mach. & Steel Casting Co.
Garrison Foundry Co., A.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Engineering Co.
Taylor-Wilson Mfg. Co.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.

Castings—Machinery.
Connellsville Fdry. Mach. & Steel Casting Co.
Mesta Machine Co.

Castings—Gray Iron and Steel.
Garrison Foundry Co., A.
Mesta Machine Co.
Morse Chain Co.
Otis Steel Co., The.
Taylor-Wilson Mfg. Co.

Cement—Fire Brick.
American Refractories Co.

Cement—Furnace—High Temperature.
Johns-Manville Co.

Central Station Equipment.
Allis-Chalmers Mfg. Co.
General Electric Co.
Smith Gas Engineering Co.
Westinghouse Electric & Mfg. Co.

Chain Grates.
Hagan, Geo. J. Co.

Channels.
Kratzer & Co., W. N.

Charging Boxes.
Blaw-Knox Co.

Chimneys—Radial Brick.
Kellogg, M. W. Co., The

Chimneys—Steel.
Kratzer & Co., W. N.

Chrome.
Harbison-Walker Refractories Co.

Chrome Brick.
American Refractories Co.

Circulating Systems for Lubricating Oil.
Bowser & Co., Inc., S. F.

Clutches—Magnetic.
Cutler-Hammer Mfg. Co.

Coal.
Combustion Eng. Corp.
McKeefrey & Co.
Stewart Iron Co.

Coal Crushers.
Orton & Steinbrenner Co.

Coal Gas Plants.
U. G. I. Contracting Co.

Coal—Plants for Powdering.
Blaw-Knox Co.

Coal Tipples and Trestles.
Blaw-Knox Co.
Mt. Vernon Bridge Co.

Cocks—Tuyere.
McCarthy, Felix.
Homestead Valve Mfg. Co.
Lawrenceville Bronze Co.

Coils and Bends—Pipe.
Pittsburgh Piping & Equip. Co.

Coke.
McKeefrey & Co.
Stewart Iron Co.

Coke Breeze.
Combustion Eng. Corp.
Garrison Foundry Co., A.
Mesta Machine Co.
National Roll & Foundry Co.
Otis Steel Co., The.
Standard Engineering Co.
United Eng. & Fdy. Co.
Wheeling Mold & Foundry Co.

Coke Ovens — By-Product—Cross Regenerators.
Hydraulic Press Brick Co.
Koppers Co., The.

Cooling Tables.
Blaw-Knox Co.

Columns.
Kratzer & Co., W. N.
Meehan Boiler & Construction Co.

Combination Gas Plants.
U. G. I. Contracting Co.

Compressed Air Locomotives.
Porter Co., H. K.

Compressors—Air.
Allis-Chalmers Mfg. Co.
Blaw-Knox Co.
General Electric Co.
Hooven, Owens, Rentschler Co.
Ingersoll-Rand Co.
Mesta Machine Co.
Westinghouse Elec. & Mfg. Co.

Commutators.
Homer Commutator Co.

Concrete — Steel Forms for Construction.
Blaw-Knox Co.

Condensers.
Blaw-Knox Co.
Mesta Machine Co.

Condensers — Barometric, Surface Jet.
Ingersoll-Rand Co.
Kellogg, M. W. Co., The
Mesta Machine Co.
Westinghouse Electric & Mfg. Co.

Condensers—Low Level Jet.
Ingersoll-Rand Co.

Condensers—Surface.
Ingersoll-Rand Co.

Connectors—Frankel Solderless.
Westinghouse Electric & Mfg. Co.

Constructing Engineers.
Dwight P. Robinson & Co., Inc.

Construction—Blast Furnace.
Arthur G. McKee & Co.
Blaw-Knox Co.
Freyn, Brassert & Co.
Laughlin & Sons Co., Alex.
Meehan Boiler & Construction Co.
McClure, G. W. & Son Co.
Mt. Vernon Bridge Co.
Smythe & Co., S. R.

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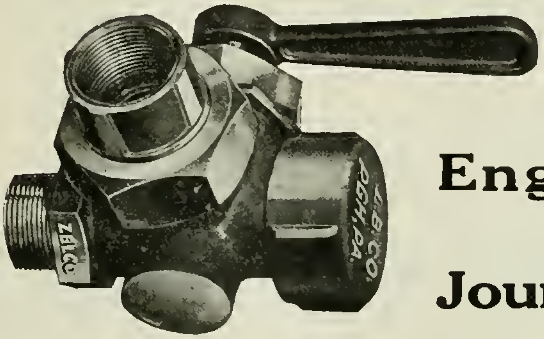
- Cinder Notches
- Cooling Plates
- Tuyere Cocks
- Hot and Cold Mill Bearings
- Pickling Crates
- Housing Nuts
- Screw Boxes
- Electrode Holders
- Machinery Brass



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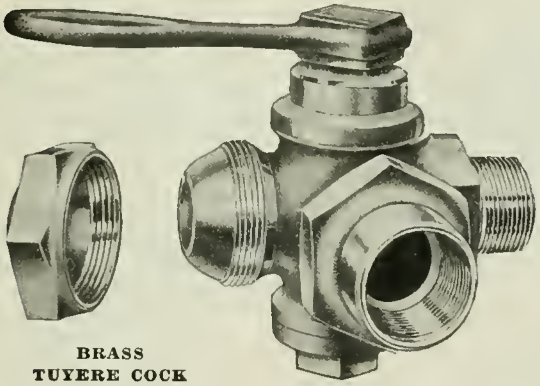

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Self-Supporting Steel Stacks, Tanks, Stand Pipes
Steel Riveted Pipe
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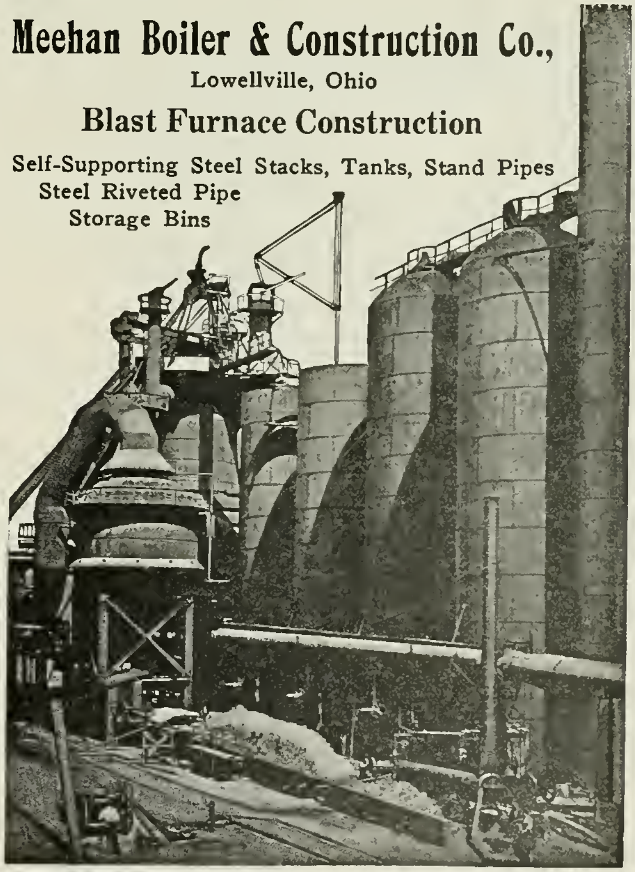

The Buyers' Guide

Construction—Gas Works.
Blaw-Knox Co.
Smith Gas Engineering Co.
U. G. I. Contracting Co.

Construction—Plate.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Mt. Vernon Bridge Co.

Construction—Structural Iron, Steel
Blaw-Knox Co.
Kratzer & Co., W. N.
Meehan Boiler & Construction Co.
Mt. Vernon Bridge Co.

Construction—Wire Work.
Kratzer & Co., W. N.

Continuous Rolling Mills.
Mesta Machine Co.
Morgan Construction Co.

Controllers—Automatic for Cranes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers—Enclosed Drum Type for Cranes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers—Electric, for Steel Mill Machinery.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Controllers—Magnetic.
Ohio Electric & Controller Co.

Controllers — Manual, Automatic, Machine Tool, Crane, Coal and Ore Bridges.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Conveyors—Billet.
Morgan Construction Co.

Cooling Beds.
Morgan Construction Co.

Cooling Plates.
Blaw-Knox Co.
Lawrenceville Bronze Co.

Core Ovens.
Electric Furnace Construction Co.

Coupling Boxes.
American Steel Foundries Co.
Garrison Foundry Co., A.
Mesta Machine Co.
National Roll & Foundry Co.
Standard Engineering Co.
Wheeling Mold & Foundry Co.

Couplings—Flexible.
Electric Controller & Mfg. Co.
Smith & Serrell
Thomas Flexible Shaft Co.

Couplings—Magnetic.
Cutler-Hammer Mfg. Co.

Couplings—Shaft.
Smith & Serrell.

Couplings—Rigid.
Smith & Serrell.

Couplings—Compression Shaft.
W. H. Nicholson & Co.

Coverings for Cold Pipes.
Johns-Manville Co.

Coverings for Pipes and Boilers.
Johns-Manville Co.

Cranes—Charging.
Northern Engineering Works.

Cranes—Electric Traveling, Gantry and Grab Bucket.
Northern Engineering Works.
U. S. Crane Co.

Cranes—Gantry.
Northern Engineering Works.
U. S. Crane Co.

Cranes—Jib and Pillar.
Northern Engineering Works.

Cranes—Coal and Ash Handling.
Northern Engineering Works.

Cranes—Dock and Wharf.
U. S. Crane Co.

Cranes—Locomotive.
Orton & Steinbrenner Co.
U. S. Crane Co.

Cranes—Pillar.
Northern Engineering Works.

Cranes—Pneumatic.
Northern Engineering Works.

Cranes—Portal.
U. S. Crane Co.

Cranes—Slag Breaking and Handling.
Northern Engineering Works.

Cranes—Transfer.
Northern Engineering Works.

Cranes—Wall and Jib.
Northern Engineering Works.

Cupolas.
Northern Engineering Works.

Cupola Linings.
Johns-Manville Co.

Cutouts.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Cut Bar Carrier.
Blaw-Knox Co.

Cyanide Pots.
Kellogg, M. W. Co., The

Cylinders.
Blaw-Knox Co.
Mesta Machine Co.

Designing and Construction Service
Dwight P. Robinson & Co., Inc.

Digesters.
Blaw-Knox Co.
Kellogg, M. W. Co., The

Disc Brakes.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.

Direct Sulphate Plants.
Semet-Solvay Co.

Doors—Open Hearth.
Blaw-Knox Co.
National Roll & Foundry Co.

Draft Gauges and Recorders.
Bacharach Industrial Inst. Co.

Drag-line Excavators.
Orton & Steinbrenner Co.

Drives—Chain.
The Medart Co

Drives—Mill.
Fawcus Machine Co.
Hooven, Owens, Rentschler Co.
Mesta Machine Co.
Morgan Construction Co.

Dryers for all Materials.
Rockwell, W. S. Co.

Dynamos.
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Efficiency Instruments.
Bacharach Industrial Inst. Co.
Bristol Co.
General Electric Co.

Electric Light Equipment.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Electric Furnaces.
Blaw-Knox Co.
Electric Fur. Construction Co.
General Electric Co.
Pittsburgh Elec. Furnace Corp.
Pittsburgh Furnace Co.
W. S. Rockwell Co.
Westinghouse Elec. & Mfg. Co.

Electric Steel Furnaces.
Electric Furnace Constr. Co.

Electric Locomotives.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electric Motors.
Electric Controller & Mfg. Co.

Electric Ovens.
Electric Furnace Constr. Co.

Electric Steam Boilers.
Electric Furnace Constr. Co.

Electric Welding Apparatus.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electrical Insulation.
Johns-Manville Co.

Elevators and Conveyors.
Orton & Steinbrenner Co.

Eliminators—Steam.
Nicholson & Co., W. H.

Engineering & Constrortion Service.
Dwight P. Robinson & Co., Inc.

Engineers—Consulting.
Arthur G. McKee & Co.
Freyn, Brassert & Co.
Laughlin, Alex. & Co.
Moore, W. E. & Co.
Morgan Construction Co.
Rockwell, W. S. Co.
Shover, Barton R.
Smythe Co., S. R., The
U. G. I. Contracting Co.

Engineers—Furnace.
Johns-Manville Co.
Electric Furnace Construction Co.
Moore, W. E. & Co.
Pittsburgh Electric Fur. Corp.
Rockwell Co., W. S.

Engineers and Contractors.
Arthur G. McKee & Co.
Dobrin, Harry
Freyn, Brassert & Co.
Garrison A., Foundry Co.
Mesta Machine Co.
Mt. Vernon Bridge Co.
McClure Son & Co., G. W.
Laughlin, Alex. & Co.
Moore, W. E. & Co.
Morgan Construction Co.
Rockwell, W. S., Co.
Smythe Co., S. R., The.
Standard Engineering Co.
Sutton-Abramsen Eng. Co.
William Swindell & Bros.
Robinson, Dwight P. Co.
U. G. I. Contracting Co.

Engines.
Allis-Chalmers Mfg. Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Engine Brasses.
Lawrenceville Bronze Co.

Engines—Gas.
Allis-Chalmers Mfg Co.
Hooven, Owens, Rentschler Co.
Mesta Machine Co.
United Eng. & Foundry Co.

Engines—Hoisting.
Mesta Machine Co.

Engines — Reversing, Blowing Pumping, Gas.
Hooven, Owens, Rentschler Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
United Eng. & Foundry Co.
Rockwell Co., W. S.

Engines—Steam.
Allis-Chalmers Mfg. Co.
Hooven, Owens, Rentschler Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
United Eng. & Foundry Co.

Equipment—Welded Chain, Wire and Wire Nail Mills—Complete.
Morgan Construction Co.

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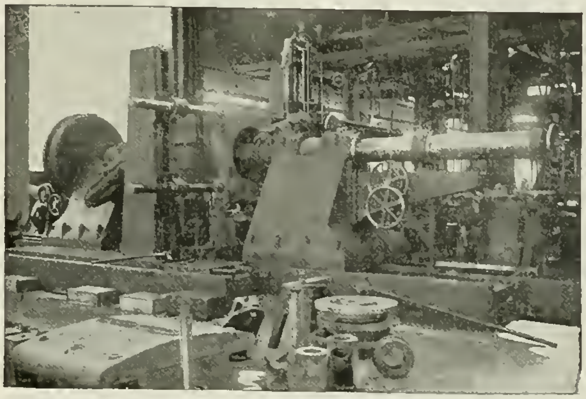

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(2) —All parts being properly proportioned;

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Hamilton Engines and Machinery
HAMILTON, OHIO

The Buyers' Guide

Expansion Joint.
Kellogg, M. W. Co., The
Smith-Serrell Co.

Expanders—Tube.
Nicholson & Co., W. H.

Fabricated Steel.
Blaw-Knox Co.

Fencing Iron.
Kratzer & Co., W. N.

Ferro-Silicon.
McKeefrey & Co.

Filtering and Circulating Systems for Lubricating Oils.
Bowser & Co., Inc., S. F.

Filters—Oil.
Bowser & Co., Inc., S. F.

Fire Brick Cement.
American Refractories Co.
Hagen, Geo. J. Co.
Johns-Manville Co.

Fire Extinguishers.
Johns-Manville Co.

Fittings, Blast Furnace and Open Hearth.
Pittsburgh Brass Mfg. Co.

Fittings—Boiler.
Pittsburgh Piping & Equip. Co.

Fittings—Lap Welded Steel Fittings—Cast Iron.
Kellogg, M. W. Co., The

Flexible Couplings.
Electric Controller & Mfg. Co.
Smith-Serrell Co., Inc.
Thomas Flexible Shaft Co.

Flow Meters.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Forgings.
Hagan, Geo. J. Co.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.
Kratzer & Co., W. N.
Mesta Machine Co.

Forging Presses.
Garrison Foundry Co., A.
Mesta Machine Co.

Forms—Steel—for Concrete Construction.
Blaw-Knox Co.

Frames—Open Hearth.
Blaw-Knox Co.
National Roll & Foundry Co.

Friction Blocks.
Johns-Manville Co.
Morgan Construction Co.

Foundry Equipment.
Pgh. Valve, Fdry. & Con. Co.

Fuel Oil.
Keystone Lubricating Co.

Furnace Alloys.
Stewart Iron Co.

Furnaces — Annealing and Case Hardening.
Electric Furnace Construction Co.
W. S. Rockwell Co.

Furnace Builders.
Arthur G. McKee & Co.
Freyn, Brassert & Co.
Hagan, Geo. J. Co.
Hydraulic Press Brick Co.
Laughlin, Alex. & Co.
McClure Son & Co., G. W.
Morgan Construction Co.
Mt. Vernon Brick Co.
Pittsburgh Electric Fur. Corp.
Pittsburgh Furnace Co.
Moore, W. B. & Co.
Rockwell, W. S. Co.
Smythe Co., S. R., The
William Swindell & Bros.

Furnace Equipment.
Blaw-Knox Co.
General Electric Co.
Rockwell, W. S., Co.
Westinghouse Elec. & Mfg. Co.

Furnaces—Forging, Heat Treating.
Hagan, Geo. J. Co.
Rockwell, W. S., Co.
William Swindell & Bros.

Furnaces—Electric.
Electric Furnace Construction Co.
Pittsburgh Electric Fur. Corp.
Pittsburgh Furnace Co.
Moore, W. E. & Co.
W. S. Rockwell Co.

Furnace Engineers.
Moore, W. B. & Co.
Pittsburgh Electric Fur. Corp.
Pittsburgh Furnace Co.
William Swindell & Bros.

Furnaces—Heating.
Rockwell, W. S., Co.

Furnace Insulation.
Johns-Manville Co.

Furnaces—Lead, Pot and Muffle Annealing, Wire Mill.
Morgan Construction Co.
Rockwell, W. S. Co.

Furnaces—Metallurgical.
Moore, W. E. & Co.
Pittsburgh Electric Fur. Corp.
Pittsburgh Furnace Co.
Rockwell, W. S., Co.

Furnaces—Reheating.
Morgan Construction Co.
Rockwell, W. S., Co.

Furnaces—Automatic Smokeless.
Rockwell, W. S. Co.

Fuses and Fuse Specialties.
D. & W. Fuse Works of General Electric Co.

Fuses.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Fuses—Renewable.
D. & W. Fuse Works of General Electric Co.
Johns-Manville Co.

Galvanizing Kettles.
Blaw-Knox Co.

Gas Burners.
Gas Combustion Co.

Gas Cleaning Plants.
Arthur G. McKee & Co.
Flinn & Dreffein Co.
Smith Gas Eng. Co.

Gas Producers.
Blaw-Knox Co.
Chapman Eng. Co.
Flinn & Dreffein Co.
The Koppers Co.
Laughlin, Alex.
Meehan Boiler & Constr. Co.
Morgan Construction Co.
Smith Gas Engineering Co.
Smythe, S. R. Co.
U. G. I. Contracting Co.
Wood, R. D. & Co.

Gas Valves.
Felix McCarthy.
Morgan Construction Co.
Rockwell, W. S., Co.
Smith Gas Engineering Co.
U. G. I. Contracting Co.

Gas Washers.
Freyn, Brassert & Co.
U. G. I. Contracting Co.

Gas Oven Plants.
Koppers Co., The

Gaskets.
Johns-Manville Co.

Gasoline and Oil Measuring Tanks and Pumps—Oil.
Bowser & Co., Inc., S. F.

Gasoline Absorption Plants.
The Koppers Co.

Gauges—Pressure, Draft, Volume.
Bristol Co.

Gears—Bevel.
Fawcus Machine Co.
Mesta Machine Co.

Gears—Compensating.
Morse Chain Co.

Gears and Gear Cutting.
American Steel Foundries.
Fawcus Machine Co.
Mackintosh, Hemphill & Co.
Medart Patent Pulley Co.
Mesta Machine Co.
Morgan Construction Co.
Morse Chain Co.
Simonds Mfg. Co., The
Taylor-Wilson Mfg. Co.
United Eng. & Foundry Co.
Woodard Machine Co.

Gears—Herringbone.
Fawcus Machine Co.
Mesta Machine Co.
Morgan Construction Co.

Gear Guards.
Blaw-Knox Co.

Gears—Spur.
Fawcus Machine Co.
Mesta Machine Co.
Morgan Construction Co.

Gear Shield.
Ironsides Co., The

Gears—Worm.
Fawcus Machine Co.
Mesta Machine Co.

Generators—D. C. and A. C.
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Girders.
Kratzer & Co., W. N.
Meehan Boiler & Constr'n. Co.
Mt. Vernon Bridge Co.

Grates.
Combustion Eng. Co.

Greases.
Keystone Lubricating Co.
Ironsides Co., The

Grease Pots.
Blaw-Knox Co.

Grinding and Polishing Machines.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Hammers—Board Steam and Steam Drop.
United Engineering & Fdy. Co.

Hauling Locomotives.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Heads—Flanged and Dished Boiler.
Blaw-Knox Co.

Hearth Jackets.
Blaw-Knox Co.

Heaters—(Electric), Air, Space, Water.
Cutler-Hammer Mfg. Co.

Heat Insulation.
Johns-Manville Co.

Heat Treating Furnaces.
Electric Furnace Const'n. Co.
W. S. Rockwell Co.

Heat Treating Furnaces—Electric.
Electric Furnace Constr. Co.

Heat Treatment.
Johns-Manville Co.

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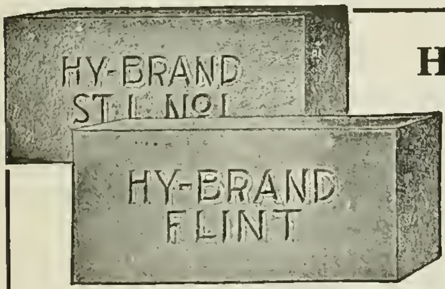

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SILICA CEMENT
OUR BRAND "MTU"
FIRE BRICK
FIRE CLAY
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Capacity 70,000,000.

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METALKASE MAGNESITE BRICK
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Conemaugh Div., P. R. R.

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Plant—Childs, Pa.
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The Buyers' Guide

Heatmeter.
Bristol Co.

Hoists—Air.
Ingersoll-Rand Co.
Northern Engineering Works.

Hoists—Electric.
Allis-Chalmers Mfg. Co.
Northern Engineering Works.

Hoists—Monorail.
Northern Engineering Works.

Holders—Gas.
Smith Gas Engineering Co.

Hoops.
West Leechburg Steel Co.

Hydraulic Machinery.
Allis-Chalmers Mfg. Co.
Birdsboro Steel Fdy. & Mch. Co.
Mesta Machine Co.

Hydraulic Packing.
Johns-Manville Co.

Hydrometers.
Taylor Instrument Co.

Hygrodeiks.
Taylor Instrument Co.

Importer and Forwarder.
Tagaris Timoleon, P.

Industrial Track.
Wheeling Mold & Fdy. Co.

Instruments—Efficiency.
Bristol Co., The
General Electric Co.

Instruments—Indicating and Recording.
Bristol Co., The

Insulating Materials — Varnish, Sheeting, Tape Compound.
D. & W. Fuse Works of General Electric Co.

Insulating Materials—Heat.
Johns-Manville Co.

Iron and Iron Ore.
McKeefrey & Co.
Stewart Iron Co.
Tod-Stambaugh Co.

Iron Soldering (Electric).
Cutler-Hammer Mfg. Co.

Journal Bearings.
Lawrenceville Bronze Co.

Keys—Machine, Self-Fitting.
Smith & Serrell

Kilns—Cement.
Blaw-Knox Co.

Ladles.
Birdsboro Steel Fdy. Mch. Co.
Blaw-Knox Co.
Meehan Boiler & Const'n. Co.

Lathes—Roll.
Garrison Foundry Co., A.
Mesta Machine Co.
Pittsburgh Rolls Corporation.
Standard Eng. Co.
United Engineering & Fdy. Co.

Lectromelt Rapid Steel Furnaces.
Pgh. Electric Furnace Corp.

Lifting Magnets.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Ohio Electric and Controller Co.

Light Oil Distillation Plants.
Semet-Solvay Co.

Limestone.
McKeefrey & Co.

Linings—Brake.
Johns-Manville Co.

Linings—Cupola.
Amer. Enam. Brick & Tile Co.
Ashland Fire Brick Co.
Clearfield Brick Mfg. Co.
Harbison-Walker Ref. Co.
Johns-Manville Co.
Kier Fire Brick Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Soisson, Jos., Fire Brick Co.

Linings—Ladle.
Amer. Enam. Brick & Tile Co.
Ashland Fire Brick Co.
Clearfield Brick Mfg. Co.
Harbison-Walker Ref. Co.
Kier Fire Brick Co.
Pyro Clay Products Co.
Mutton Hollow Fire Brick Co.
Soisson, Jos., Fire Brick Co.
Taylor, Chas. P.

Liquid Level.
Bristol Co.

Locomotives and Special Cranes.
Orton & Steinbrenner Co.

Locomotives—Electric.
Baldwin Locomotive Works.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Locomotives — Steam, Compressed Air, Storage Steam.
Porter, H. K. Co.
Baldwin Locomotive Works.

Locomotives—Storage Battery.
General Electric Co.

Lubricants—Gear, Wire Rope, Etc.
Keystone Lubricating Co.
Ironsides Co., The

Machinery Brass.
Lawrenceville Bronze Co.

Machinery—Hydraulic.
Allis-Chalmers Mfg. Co.
Birdsboro Steel Fdy. & Mch. Co.
Mesta Machine Co.
United Engineering & Fdy. Co.

Machinery—Rolling Mill.
Birdsboro Steel Fdy. & Mch. Co.
Connellsville Foundry Mach. & Steel Casting Co.
Garrison, A., Foundry Co.
Hooven, Owens, Rentschler Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Construction Co.
National Roll & Foundry Co.
Pittsburgh Rolls Corporation.
Standard Engineering Co.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.
Woodard Machine Co.
Youngstown Fdy. & Mch. Co.

Machinery—Special.
Connellsville Fdry., Mach. & Steel Casting Co.
Garrison, A., Foundry Co.
Hooven, Owens, Rentschler Co.
Mesta Machine Co.
Simonds Mfg. Co., The
United Engineering & Fdy. Co.
Woodard Machine Co.

Machinery—Tin Plate.
Garrison, A., Foundry Co.
Mesta Machine Co.
Northern Engineering Works.

Machinery—Transmitting.
Mesta Machine Co.

Machinery—Wire Drawing, Wire and Rivet Works.
Morgan Construction Co.
Shuster Co., F. B.

Machinery and Supplies—Mining.
Meehan Boiler & Const'n. Co.

Machinery—Wire Mill.
Morgan Construction Co.

Machinery—Tin Plate.
Garrison Foundry Co., A.
Mesta Machine Co.
Northern Engineering Works.

Machine Work.
Connellsville Fdry., Mach. & Steel Casting Co.
Hooven, Owens, Rentschler Co.

Machines—Straightening.
The Medart Co.
Morgan Construction Co.
Shuster Co., F. B.
Sutton-Abramsen Eng. Co.

Magnesia Brick.
American Refractories Co.

Magnesite.
American Refractories Co.

Magnetic Clutches, Brakes, Separators.
Cutler-Hammer Mfg. Co.

Magnets—Electric Lifting.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Ohio Electric & Controller Co.

Melting and Refining Furnaces.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Metal—Bearing.
Lawrenceville Bronze Co.

Metalkase Magnesite Brick—McCallum Patent.
Harbison-Walker Refract. Co.

Meters—Flow.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Meters—Gas and Air.
Bacharach Industrial Inst. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
U. G. I. Contracting Co.
Westinghouse Elec. & Mfg. Co.

Meters for Oil—Kerosene, Gasoline.
Bowser, S. F. & Co., Inc.

Meters—Recording.
Bristol Co., The
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Mill Bearings—Roller.
Hyatt Roller Bearing Co.

Mills—Continuous Rolling.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Construction Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Eng. Co.
Treadwell Engineering Co.
United Eng. & Foundry Co.

Mill Drives.
Fawcus Machine Co.
Mesta Machine Co.

Mills—Blooming, Universal, Plate, Sheet, Tin and Bar.
Mesta Machine Co.
Treadwell Engineering Co.

Mills—Wire, Complete Equipment.
Morgan Construction Co.

Mixers—"Blaw."
Blaw-Knox Co.

Molds—Ingot.
Wheeling Mold & Foundry Co.

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Semet-Solvay Co.

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The Buyers' Guide

Motors—Electric Steel Mill.
Allis-Chalmers Mfg. Co.
General Electric Co
Westinghouse Electric & Mfg. Co.

Motor Operated Brakes.
Cutler-Hammer Mfg. Co.

Mud Guns and Holding Down Machines.
Arthur G. McKee & Co.
McCarthy, Felix.

Nitrogen.
Linde Air Products Co.

Oils—Engine.
Ironsides Co.
Keystone Lubricating Co.

Oil Engines.
Ingersoll-Rand Co.

Oil Filters.
Blaw-Knox Co.
Bowser, S. F. & Co., Inc.

Oil Fuse Cutouts (Aerial and Underground.
D. & W. Fuse Works of General Electric Co.

Oil Meters.
Bowser, S. F. & Co., Inc.
General Electric Co.

Oil Pumps.
Bowser, S. F. & Co., Inc.

Oil Storage and Distributing Systems.
Bowser, S. F. & Co., Inc.

Oil Tanks.
Blaw-Knox Co.
Bowser, S. F. & Co., Inc.

Ore.
McKeefrey & Co.
John A. Savage Co.
Stewart Iron Co.
Tod-Stambaugh Co.

Ovens—Core.
Electric Furnace Const'n. Co.

Ore, Coal and Ash Handling Equipment.
Arthur G. McKee & Co.
Blaw-Knox Co.

Oxy-Acetylene.
Linde Air Products Co.

Oxygen.
Linde Air Products Co.
Oxweld Acetylene Co.

Packing.
Johns-Manville Co.

Paints—Metal and Wood.
Koppers Products Co.

Palm Oil Plants.
Blaw-Knox Co.

Penstocks.
Blaw-Knox Co.
Kellogg, M. W. Co., The
National Roll & Fdy. Co.

Pig Iron.
McKeefrey & Co.
Stewart Iron Co.
Tod-Stambaugh Co.

Pinions—Mill.
American Steel Foundries Co.
Birdsboro Steel Fdy. & Mch. Co.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Construction Co.
National Roll & Foundry Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Engineering Co.
Otis Steel Co., The.
Simonds Mfg. Co.
United Eng. & Foundry Co.
Wheeling Mold & Foundry Co.
Woodard Machine Co.

Pipe.
Pittsburgh Piping & Equip Co.

Pipe—Bends and Coils.
Kellogg, M. W. Co., The
Pittsburgh Piping & Equip. Co.
Taylor-Wilson Mfg. Co.

Pipe—Riveted Steel.
Blaw-Knox Co.
Meehan Boiler & Constr'n. Co.

Pipe—Wrought Iron.
Pittsburgh Piping & Equip. Co.

Piping.
Kellogg, M. W. Co., The
Pittsburgh Piping & Equip. Co.

Pipe Covering—Asbestos and Magnesia.
Johns-Manville Co.

Pipe Cutting and Threading Machines.
Standard Engineering Co.
Pittsburgh Piping & Equip. Co.
Taylor-Wilson Mfg. Co.

Pipe—Fittings.
American Steel Foundries.
Kellogg, M. W. Co., The
Pgh. Valve, Fdry. & Constr. Co.

Pipe Mill Machinery.
Garrison, A., Foundry Co.
Mesta Machine Co.
Pittsburgh Piping & Equip. Co.
Standard Engineering Co.
Taylor-Wilson Mfg. Co.
United Engineering & Fdy. Co.

Piston Rods.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.
Mesta Machine Co.

Plate and Structural Iron Work.
Kratzer, W. N. & Co.
Otis Steel Co.

Pneumatic Tools.
Ingersoll-Rand Co.

Ports—Open Hearth.
Blaw-Knox Co.
Birdsboro Steel Fdy. & Mch. Co.
National Roll & Fdy. Co.

Pots, Annealing—Forge and Hammer.
Kellogg, M. W., Co., The

Pots, Annealing—Lap Welded.
Kellogg, M. W. Co., The

Power Transmitting Machinery.
Mesta Machine Co.

Powdered Coal Equipment.
Aero Pulverizer Co.

Preheaters.
Badenhausen, Phillips.

Presses—Forging.
Garrison, A., Foundry Co.
Mesta Machine Co.
United Engineering & Fdy. Co.

Presses—Hydraulic.
Birdsboro Steel Fdy. & Mch. Co.
Garrison, A., Foundry Co.
Mesta Machine Co.
United Engineering & Fdy. Co.

Presses—Rail Straightening.
Garrison, A., Foundry Co.

Pressure Packed Valves.
Homestead Valve & Mfg. Co.

Pressure and Vacuum.
Bristol Co.

Producers—Gas Automatic.
Wood, R. D. & Co.

Producers—Gas.
Blaw-Knox Co.
Chapman Eng. Co.
Laughlin, Alex. & Co.
Morgan Construction Co.
Smith Gas Engineering Co., The
S. R. Smythe Co., The
U. G. I. Contracting Co.
Wood, R. D. & Co.

Pulleys and Clutches.
The Medart Co.
Mesta Machine Co.

Pulverizers.
Aero Pulverizer Co.

Pulverized Coal Equipment.
Aero Pulverizer Co.
Combustion Eng. Co.

Pumps—Air.
Ingersoll-Rand Co.

Pumps.
Allis-Chalmers Mfg. Co.
Birdsboro Steel Fdy. & Mch. Co.
Hooven, Owens, Rentschler Co.
Mesta Machine Co.

Pumps—Centrifugal.
Allis-Chalmers Mfg. Co.

Pumps—Electric.
Allis-Chalmers Mfg. Co.

Pumps (Hand or Power) — Oil, Gasoline.
Bowser, S. F. & Co., Inc.

Pump Valves.
Johns-Manville Co.

Pyrometers—Indicating, Recording
Bacharach Industrial Inst. Co.
Bristol Co., The
Taylor Instrument Co.

Railway Equipment.
American Steel Foundries.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Recording Thermometers.
Bristol Co.

Recording Instruments.
Bacharach Industrial Inst. Co.
Bristol Co.

Recording and Index Thermometers.
Taylor Instrument Co.

Reels—Wood and Iron, Wire Mills.
Morgan Construction Co.

Refractory Linings and Cement.
Johns-Manville Co.

Refrigeration Machines.
Johns-Manville Co.

Regulators.
Bristol Co.

Regulators—Automatic.
Cutler-Hammer Mfg. Co.
Bristol Co.
Electric Controller & Mfg. Co.

Relays—Field Rheostat.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Renewable Fuses.
General Electric Co.
Johns-Manville Co.

Resistance—Cast Grid and Coil.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Electric Controller & Mfg. Co.
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The Buyers' Guide

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Mesta Machine Co.

Riveted Piping.
Meehan Boiler & Constr. Co.

Rocking Mill.
Mackintosh-Hemphill Co.

Rod Mills.
Morgan Construction Co.
Standard Engineering Co.

Rods—Piston.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.
Mesta Machine Co.

Rolls—Sand, Chilled and Steel.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
National Roll & Foundry Co.
Otis Steel Co.
Pittsburgh Iron & Steel Fdys. Co.
Pittsburgh Rolls Corporation.
Standard Engineering Co.
United Engineering & Fdy. Co.
Youngstown Fdy. & Mch. Co.

Roll Lathes.
Mesta Machine Co.
Standard Engineering Co.

Roll Neck Lubricant.
Ironsides Co., The

Roller Bearings.
American Roller Bearing Co.
Hyatt Roller Bearing Co.

Rotary Kilns.
Kellogg, M. W. Co., The

Rolling Mill Machinery.
Hooven, Owens, Rentschler Co
Mesta Machine Co.
Morgan Construction Co.
National Roll & Foundry Co.
Standard Engineering Co.

Rolling Mill Equipment.
Birdsboro Steel Fdry. & Mch. Co.
Connellsville Foundry Machine & Steel Casting Co.
Garrison, A., Foundry Co.
Hooven, Owens, Rentschler Co.
Mackintosh-Hemphill Co.
Mesta Machine Co.
Morgan Construction Co.
National Roll & Foundry Co.
Standard Eng. Co.
Sutton-Abramsen Engr. Co.
United Engr. & Fdry Co.
Wheeling Mold & Foundry Co.
Woodard Machine Co.

Roofings—Fireproof.
Johns-Manville Co.

Roofs and Buildings—Iron.
Kratzer, W. N. & Co.
Mt. Vernon Bridge Co.

Rope Dressing.
Keystone Lubricating Co.

Saws — Metal Cutting, Inserted Teeth.
Standard Engineering Co.

Scientific Instruments.
Bristol Co.

Scrap Buckets.
Blaw-Knox Co.

Screw Stock.
Union Drawn Steel Co.
West Leechburg Steel Co.

Separators—Magnetic.
Cutler-Hammer Mfg. Co.

Separators—Steam.
Nicholson & Co., W. H.

Shafting.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.
The Medart Co.
Union Drawn Steel Co.
West Leechburg Steel Co.

Shaft Couplings.
Smith & Serrell.

Shaft Hangers.
The Medart Co.

Shapes—Special Steel.
Union Drawn Steel Co.
West Leechburg Steel Co.

Shears—Angle and Plate.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.

Shear Blades.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.

Shears—Billet, Bloom and Slab.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.
Woodard Machine Co.

Shears—Guillotine.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.

Shear Knives.
Heppenstall Forge & Knife Co.
Heppenstall Forge Co.

Shears—Portable, Motor Driven.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.

Shears—Scrap, Alligator, Wire.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.
Youngstown Fdy. & Mch. Co.

Shears—Squaring.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Standard Engineering Co.
United Engineering & Fdy. Co.

Shearing—Machines.
Garrison A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Construction Co.
Standard Engineering Co.

Sheets—Steel and Iron.
Otis Steel Co.

Sheet and Tin Mill Equipment.
Blaw-Knox Co.
Mesta Machine Co.

Sheet Packing.
Johns-Manville Co.

Sheet Pack and Bar Carriers.
Blaw-Knox Co.

Silica Brick.
American Refractories Co.
Harbison-Walker Refract. Co.

Silica Clays.
Harbison-Walker Refract. Co.

Silicon.
McKeefrey & Co.

Skip Hoists.
Arthur G. McKee & Co.

Skip Cars.
Youngstown Fdy. & Mch. Co.

Soaking Pit Covers.
Wheeling Mold & Foundry Co.

Solderless Connectors—Frankel.
Westinghouse Electric & Mfg. Co.

Soot Blowers.
Diamond Power Specialty Corp.

Special Machinery.
Sutton-Abramsen Eng. Co.

Spindles—Mill.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Pittsburgh Rolls Corporation.
Standard Engineering Co.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.

Sprocket Wheels.
The Medart Co.

Stacks—Steel.
Blaw-Knox Co.
Meehan Boiler & Constr. Co.

Stampings—Steel.
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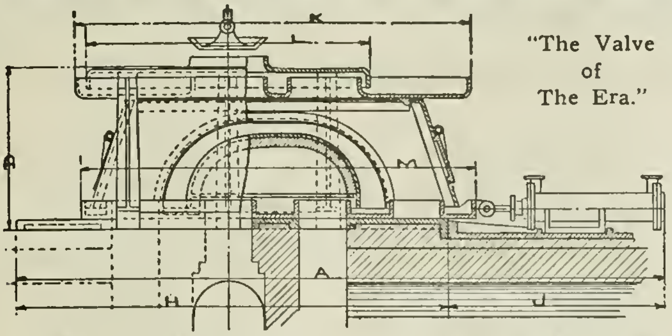

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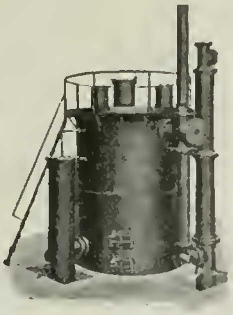

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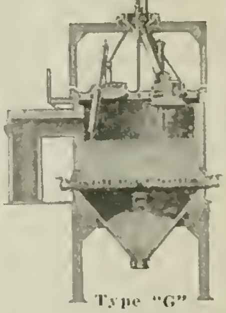

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